SHEET COPPER
HANDBOOK

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SECOND EDITION

ANACONDA AMERICAN BRASS LIMITED
NEW TORONTO, ONTARIO

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SHEET COPPER

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Reg. U. S. Pat. Off.

A HANDBOOK FOR ARCHITECTS AND SHEET METAL WORKERS — ON THE APPLICATION OF SHEET COPPER IN THE CONSTRUCTION OF BUILDINGS . . .

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FOREWORD

SHEET COPPER supersedes previous editions of COPPER ROOFINGS and COPPER FLASHINGS. It not only contains revisions and rearrangements of all the important details of sheet copper application in building construction which appeared in those handbooks, but also has much new data on the subject. This information was obtained through research and from the practical experience of leading authorities acknowledgment of which is made on the following page.

In the Second Edition the sections of the book dealing with the treatment of copper work, cleaning, coloring and finishing, lead-coated copper, etc., have been revised. Sections on Termite and Lightning Protection have been added. Details for Reglet and for Batten Seam Roofing construction have been modified. Other changes are minor and are editorial or clarifying in character.

We realize that no work of this kind can ever be complete and if there are any questions as to situations not covered herein, we will be glad to advise you as to the best current practice.

We would especially emphasize the fact that proper application is a prime requisite for satisfactory service from a copper roof. Attention to details as well as to general considerations is very essential. All too often proper provision for expansion and contraction is not made, and this is the root of nearly all the trouble with copper roofing work that has ever been called to our attention.

TO ARCHITECTS AND BUILDERS:

In presenting the details, instructions and sketches in this book, we have endeavored to make them as complete and accurate as possible. Copper is a good roofing material and, properly handled, will give long and satisfactory service. Good material deserves good treatment. The time to be sure the design is right is before application, not after.

It is highly important that in having the work done the services of a competent and reliable sheet metal firm be employed. A contract placed solely on the basis of price will be just that and nothing more, no matter how detailed the specifications may be.

TO SHEET METAL WORKERS:

Upon the skill and craftsmanship of a good mechanic depends the successful application of copper or any other roofing material. That is why in this book we have presented data covering only the basic principles of application of the metal. We have not attempted to cover all situations, alternate methods of construction or special problems that may be met from time to time.

ACKNOWLEDGMENT

THE Association acknowledges with thanks the assistance given by many interested organizations and individuals in the preparation of the original edition of this book. We also deeply appreciate the constructive criticism that has made possible the changes in the Second Edition which we believe increase its usefulness. In addition to assistance rendered by member companies, the Association wishes particularly to acknowledge the cooperation of the following:

American Face Brick Association
American Institute of Architects, Structural Service Department
Associated Tile Manufacturers
Atlantic Terra Cotta Company
Atlas Roofing Company
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The Sheet Metal Worker
Thompson-Starrett Co., Builders
Trowbridge & Livingston, Architects
Turner Construction Co., Builders
Voorhees, Gmelin & Walker, Architects
Warren & Wetmore, Architects
Max Walten, Roofer

GENERAL NOTES

1. **Distortion.** The distortion of some details will be apparent at first glance. This has been done for emphasis so that the treatment of the copper will be clear. In some cases the drawings have been simplified by not showing all the clearances to scale. Accompanying text matter should accordingly always be considered in conjunction with all details.

2. **Building Paper or Felt.** The use of building paper or felt with all copper roofing and flashings is recommended. To avoid confusion it has been omitted from the drawings.

3. **Patented Devices.** Practically no details involving patented roofing, flashing or drainage devices have been shown. Some of these can be recommended and those which represent quality products would have our endorsement.

4. **Nails, Etc.** All nails, bolts, and other fastenings for copper work should be of copper or of high copper content copper alloy. In the text that follows we use the terms copper, brass or bronze in describing these fastenings indiscriminately and they should not be taken as mutually exclusive.

TEN RULES OF APPLICATION

RULE 1. IN GENERAL USE 16-OZ. SOFT (ROOFING TEMPER) COPPER.

(A) Use hard (cornice temper) copper only where specifically indicated.

RULE 2. PREPARE THE LAYING SURFACE CAREFULLY AND SEE THAT IT IS SMOOTH AND EVEN.

(A) All roofing, flashings, gutter-linings, etc., should be laid on a good building paper or roofing felt.

(B) Sheathing boards should be thoroughly dry when copper is laid.

(C) All nail heads should be set.

RULE 3. AVOID SHARP BENDS IN COPPER.

(A) Bend the sheets as little as possible before laying.

RULE 4. NEVER SECURE COPPER SHEETS IN ANY WAY WHICH WILL PREVENT FREE MOVEMENT OF THE METAL.

(A) Never carry a copper sheet more than three or four inches over an angle.

(B) Break the sheet and lock it to the adjoining one. This allows for movement.

RULE 5. USE CLEATS RATHER THAN NAILS WHEREVER POSSIBLE WITH COPPER SHEETS.

(A) By "sheet" is meant any piece over twelve inches wide.

(B) Use two-nail cleats two inches wide and place them not more than twelve inches apart.

RULE 6. USE COPPER, BRASS OR BRONZE NAILS ONLY FOR FASTENING STRIPS AND CLEATS.

(A) Flat-head wire nails are best.

(B) Nails should be spaced four inches maximum.

RULE 7. MAKE AMPLE SIZE JOINTS AND SEAMS.

(A) Standing seams at least one inch finished.

(B) Flat-lock seams at least ½ inch finished.

(C) Lap seams to be soldered at least ¾ inch finished. Unsoldered wider depending on the pitch.

(D) Double-lock seams at least ½ inch finished.

(E) Lay seams so that water drains over, not against, them.

RULE 8. TIN CAREFULLY AND THOROUGHLY.

(A) Pre-tinning makes the best seams.

(B) Use heavy tinning coppers.

(C) Use enough tin or solder to cover all the surface.

RULE 9. USE ROSIN AS A FLUX RATHER THAN ACID OR PREPARED FLUXES.

(A) If acid is used see that it is properly and thoroughly killed.

(B) If acid or a prepared flux is used see that it is thoroughly washed off.

RULE 10. SOLDER WELL FLOWED OVER AND SWEATED IN MAKES STRONG SEAMS.

(A) Use the best half-and-half solder.

(B) Heat the seam thoroughly.

(C) Heavy, hot coppers are essential.

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The copper roof on Christ Church, Philadelphia, shown above, is now at the end of its second century of satisfactory service. This roof is of standing seam construction, with unsoldered cross seams. The gage of the copper is that of the present standard 16-ounce.

SECTION I—GENERAL

VARIOUS PROPERTIES OF COPPER

The first essential in building construction is stability; and second only to this is the requirement that the materials used withstand the attack of the elements. Nature does her work slowly, but when she combines her weapons of wind and rain, ice and snow, heat and lightning, erosion and corrosion, not many years elapse before the structure may succumb. Copper has the necessary characteristics to protect a structure against these attacks at its vital point, the roof. A building is only as good as the roof which covers it.

Copper combines durability, lightness in weight, ease of handling, beauty and economy to such a marked degree, besides being fire resistant, that it is the most practical material for roofing, flashings, gutters and downspouts.

The value of any product can be measured by the degree of its public acceptance. On important structures such as Government buildings, public halls, hospitals, churches and cathedrals—those built for permanence—copper enjoys wide use.

DURABILITY OF COPPER

Copper is one of the least chemically active of the ordinarily used commercial metals. This gives it high resistance to corrosion from air, water, and acid solutions which may develop from the atmosphere. It is rust-proof, and therein lies the key to the lasting qualities of a copper roof. If properly applied it affords insurance against leaks which might result in costly repairs to the building interior as well as maintenance expense on the roof itself.

The need for durability is especially important in flashings, gutters, and downspouts. Flashings are intended to insure against leakage at critical localities, such as at joints and around openings, in exposed surfaces of structures. Gutters and downspouts must carry away the water shed by roof surfaces. These parts of the roof undergo severe service, and copper stands the strain better than rustable metal. Moreover, copper is fireproof. As its electrical conductivity is high, a copper roof, properly grounded, provides the best possible protection against lightning.

Numerous important buildings, as well as many fine residences, in the United States have copper roofs many years old; in Europe and Asia are other examples which have lasted for centuries. Here follows a partial list of copper roofs, from all over the world, still giving satisfactory service without costly repairs.

EXAMPLES OF COPPER ROOFING

Building	Date
Hildesheim Cathedral, Germany	1320
Cathedral, Basle, Switzerland (flashings)	1350
St. James's Palace, London	1520
St. Peter's, Rome (flashings)	1550
Holy Ghost Church, Copenhagen (tower)	1582
Kronberg Castle, Elsinore, Denmark	1585
Nagoya Castle, Japan	1610
The Bourse, Copenhagen, Denmark	1624
Rosenborg Castle, Copenhagen	1640
Drottningholm Castle, Sweden	1662
Town Church of Tilsit, Germany	1695
The Zwinger, Dresden, Germany	1711
St. Hedwig's Church, Berlin	1723
Christ Church, Philadelphia	1737
The Naval Guard House, Copenhagen (tower)	1744
St. Peter's Church, Copenhagen (tower)	1756
Christians Church, Copenhagen (tower)	1769
Customs House, Dublin	1791
Cathedral of Notre Dame, Montreal	1824
United States Capitol, Washington (section of roof)	1827
Bodleian Library, Oxford	1830
Bacon residence, Madison, Ga.	1832
Chartres Cathedral, France	1836
State Capitol, Jackson, Miss.	1839
British Museum, London (dome)	1840
York Minister, York, England	1842
Church of the Madeleine, Paris	1842
Trinity Church, New York	1846
Bonsecours Church, Montreal	1848
State Capitol, Boston, Mass. (dome)	1850
St. James Cathedral, Montreal (domes)	1852
Antioch College, Yellow Springs, Ohio	1862
Opera House, Paris	1865

ECONOMY IN ITS USE

The first cost of copper is its only cost, if properly applied. Initially, it will be slightly more expensive than rustable metal, but such slight excess will be trifling when compared with the total cost of the building. Labor charges for metal applications will be about the same. The long-run economy to be obtained by the use of copper for roofing, flashings and gutters and downspouts accrues through freedom from charges for maintenance or replacement frequently accompanied by the necessity for costly scaffolding.

Copper's salvage value is an item to be considered by the prudent builder. In the event of the destruction or demolition of a building, copper always can be sold for a fair price.

ATTRACTIVE IN APPEARANCE

Nature acts as the decorator of copper. In time she forms an attractive green coating known as "patina" which enhances the beauty of the structure and acts as a shield against deterioration. Copper requires no painting or other protective treatment. Lead-coated copper may be used for grey tones, if preferred to the green patina mentioned above.

The roof is more than a mere cover for the building. It gives dignity, character and beauty; and the design and color are important to harmony. Happily, the practical problems of applying copper sheet have worked out so that the three types of construction—flat-lock seam, standing seam, and ribbed or batten seam—all lend themselves admirably to certain classes of buildings.

In the residential field, particularly, the temptation often arises to avoid the expense of an architect. This is poor economy, for professional advice often is justified for the choice of roof style alone. There are only a few pure roof types, but these can be combined in many ways to obtain an artistic appearance.

EASE OF APPLICATION

Ductility and malleability are the general terms used to describe the capacity of a metal to be stretched without rupture. The first is usually applied to drawing, the second to hammering operations.

Copper is one of the most ductile of metals. This permits of easy working, and helps make it an ideal metal for roofing sheets. Through this inherent quality it can be moulded without difficulty to the contour of domes or cornices, as well as bent to form locks or valleys. Copper sheets can be obtained in hard or soft grades, and each has its place in sheet metal work, as is explained under "Temper".

LIGHT IN WEIGHT

Copper's corrosion resistance makes it possible to use a thin sheet so it becomes one of the lightest of roofs, thus eliminating heavy supporting structures. The weights of various roofing materials are as follows:

Material	Weight of 100 Sq. Ft. Laid
Clay Shingle Tile	1000-2000 lbs.
Clay Spanish Tile	800-1500 "
Slate	500-1600 "
Felt and Gravel (Slag 100 lbs. less)	530- 715 "
Asbestos Shingles	265- 650 "
Hard Lead Sheets	250- 600 "

Material	Weight of 100 Sq. Ft. Laid
Wood Shingles	200-300 lbs.
20 g. Galv. Iron (Corrugated)	150-225 "
Asphalt Shingles	130-325 "
16 oz. Copper	120-140 "
Copper Shingles and Tile	95-150 "
Tin	75-150 "

TEMPER OF COPPER SHEETS

Copper sheets are made in varying degrees of temper, or hardness. Experience has established two of these as best suited for building construction. The industry has come to know these as "soft" or "hot-rolled", and "hard", or "cold-rolled" copper; and it is common practice so to designate the sheets in specifying or ordering. These terms sometimes have caused misunderstanding and it is recommended that the two tempers be referred to as "roofing temper" and "cornice temper". The manufacturers know definitely what these degrees of hardness are; the first is soft-rolled and the second hard-rolled, to be sure, but the amount of temper is fixed. The trade and the architectural profession, therefore, are urged to employ the following terms, which are in fairly general use:

Instead of	Use
Soft Soft-rolled Hot-rolled	Soft (Roofing Temper) *abbrev.* (*R. T.*)
Hard Hard-rolled Cold-rolled	Hard (Cornice Temper) *abbrev.* (*C. T.*)

TEMPER FOR VARIOUS USES

Use soft (*R.T.*) copper for roofing and all flashing and counter-flashing work; also in all other places where the shaped or formed work is supported, such as in built-in or box gutter linings, etc.

Use hard (*C. T.*) copper for all hanging gutters, eaves troughs, downspouts, cornices—or wherever stiffness is necessary to support or maintain the shape and contours of the work.

WEIGHTS AND GAUGES

Copper sheets are made in all weights and gages up to a thickness of one-quarter inch. Thicknesses greater than that usually are classed as plates or slabs. The gage of sheet copper is defined by the ounce weight per square foot: "16-oz. copper" means copper weighing 16 ounces per sq. ft. Page 123 gives a table of weights and gages.

In the past it has been the usual practice, wherever copper sheet metal work was to be used in building, to specify 16-ounce copper without special regard to the exposure to which it was to be subjected. Recent years have brought about the realization that conditions of usage and exposure vary, and it thus seems logical that the weight of copper sheet used should be governed, in some measure, by the type of service required of it.

Sixteen-ounce copper has been shown by experience to be the minimum weight suitable for flashings, gutters and leaders, and for roofing work on large structures and in congested localities. Copper installations which have lasted through the years are 16-ounce or heavier, and present-day conditions in and near our populous industrial cities, with soot and gas-laden atmospheres, are more severe than those of the past. Under special conditions of unusual exposures or heavy duty, where corrosion or erosion or both are severe, the weight of copper should be increased. On roofs of heavy slates or tiles, for instance, 18-ounce or 20-ounce copper flashing is recommended, and this would hold wherever there is unusual wear.

In suburban or rural locations, copper lighter than 16-ounce has been advocated and is being used for sloping roofs of residences and for small roof areas. Even in such instances, however, we recommend that 16-ounce copper be used for flashings, valleys, leaders and gutters. Further, nothing lighter than 16-ounce copper should be used for flat areas, which demand the soldered flat seam construction, and where conditions are more severe than on steep slopes.

There are bound to be slight variations in the thickness, and correspondingly in the weight, of rolled metal sheets or strips. The accepted tolerance practice is given on page 127. Further data on the physical properties of copper will be found on page 121.

DISSIMILAR METALS—ELECTROLYSIS

Dissimilar metals, when in contact in the presence of an electrolyte, set up galvanic action resulting in the deterioration of one of them. The following table lists the more common commercial metals according to what is known as the electro-chemical series:

1. Aluminum	5. Nickel
2. Zinc	6. Tin
3. Steel	7. Lead
4. Iron	8. Copper

When any two metals in this list are in contact, with an electrolyte present, the one with the lower number is corroded. For example, if number 3 and number 8 are in contact, the steel will be corroded. This phenomenon must be kept in mind wherever two or more metals are used in construction; for the electrolyte may be formed from water or moisture creating solutions from ingredients in the atmosphere.

Such galvanic action, for the purpose of this discussion, increases as the metals are farther apart in the accompanying list. Hence, if iron (or steel) and copper are in contact with moisture, the iron or steel is corroded. A similar tendency exists between lead or tin and copper, but here the potential is much less so that no injurious results are produced, especially if water is the electrolyte.

Where possible only copper or high-copper alloys should be used in connection with copper work, as, for instance, nails, screws, and fastenings. If the use of other metals is unavoidable, any possibility of galvanic action should be guarded against by proper insulation. This problem arises most commonly when ferrous metals are involved, and insulators for such cases are listed below in the order of recommended practice:

1. Asbestos — frequently used in skylight construction.
2. Strips of sheet lead between the metals.
3. Heavy tinning of the ferrous metal.
4. Good quality, moisture-proof, building paper or felt.
5. Heavy coat of asphalt paint.

EXPANSION AND CONTRACTION

Copper expands and contracts more than some building materials, but not as much as others; and this movement can be allowed for by proper installation.

Following is given the movement, for a 150° F. change in temperature, of an eight-foot sheet of the principal metals used in building work:

	Inches	About
For steel—hard	0.1051	7/64
" " soft	0.0878	5/64
" iron	0.0965	6/64
" monel metal	0.1104	7/64
" copper	0.1340	9/64
" aluminum	0.1843	12/64
" lead	0.2331	15/64
" zinc—rolled	0.2492	16/64

The above table shows that, because of the relative values of the metals' coefficient of expansion, for a given temperature variation there will be more movement in copper than in iron, steel or monel, and less than in aluminum, lead or zinc.

Temperature conditions at the time the work is done must be considered by contractors in allowing for expansion and contraction. Metal laid during warm weather needs little room for expansion; but it does require ample provision for the contraction which comes with cold weather. The reverse is true, of course, of work done in cold weather, when contractors must provide ample room for expansion.

Copper never fails from expansion and contraction if properly installed. Individual installations present varying problems for taking care of such movements, and these are brought out fully in the details which follow in the later pages of this book. There are many instances where it is desirable to use sheets smaller than those usually employed or where solder, not being required, should be omitted to allow movement.

CHANGES IN TEMPERATURE

To obtain data on the temperature changes to be expected in sheet copper work an investigation was undertaken at the Bureau of Standards, Washington, D. C. Continuous records of the temperature of a copper roof for about one year were obtained to determine the maximum and minimum reached and also the rate of change. Simultaneous air temperatures were measured during a part of the same period.

The results showed that during the night the roof temperature remained quite uniform. It dropped slowly to a minimum which occurred nearly always at 5 o'clock in the morning. While the sun was down, the roof temperature ran slightly less than the air temperature. This effect was noticeable on all clear nights and was due to the radiation of heat from the copper to the atmosphere. This undercooling averaged about 10° F. and a maximum of 16° was obtained.

At sunrise, the roof temperature began to rise sharply, at first in a fairly uniform manner but as the sun got higher small fluctuations of four or five degrees began to appear. The effect of occasional clouds was very marked in causing a drop in the roof temperature even though the air temperature was not perceptibly affected. The record for the afternoon was similar to that of the morning but, of course, with decreasing temperatures. The difference between roof and air temperatures (superheat) when the sun was shining, was very large.

On rainy days, or days when the sun was completely obscured by heavy clouds, the record was similar to that at night except that the roof temperature virtually was the same as that of the air.

For design purposes the maximum fluctuations in the roof temperature throughout the year must be considered. The summarized data for the investigations in Washington are as follows:

Max. roof temp.	July 22	147°
Corresponding air temp.		103°
Min. roof temp.	Jan. 29	10°
Corresponding air temp.		11°
Max. superheat	April 10	58°
Max. under-cooling	June 15	16°
Max. rate of change in 6 hrs.		0.2° per min.
Max. rate of change in 30 min.		1.5° per min.
Max. rate of change in 5 min.		7.2° per min.
Max. aver. daily range (month)	May, 1926	63°
Corresponding aver. daily temp. range		18°

The roof studied, that of the National Museum, had been in service long enough to develop a uniform green patina, so the results obtained should be fairly representative of the temperatures to be expected on the average copper roof. New copper would have a lower coefficient of absorption and a higher coefficient of reflection, and hence would show a lower range of temperature.

Radiation emitted from the copper at night seems to be nearly constant during the year, the average undercooling being about 10° F. on clear nights.

Assuming a maximum possible superheat of 75° and an air temperature of 105°, it appears that under exceptional circumstances a copper roof may reach a temperature of 180° F. The recorded maximum of 147° was on an exceptionally hot day. Probably over most of the United States a temperature of 150° will rarely be exceeded.

It is worth while again to stress the importance of taking into consideration the roof temperature at the time the roof is laid. If the metal is placed in hot weather, provision must be made for contraction resulting from a change down to the coldest air temperature expected in the locality. If the metal is applied in cold weather the opposite conditions prevail, and expansion movement should be calculated and provided for by adding from 50° to 75° to the maximum air temperature which develops during the Summer.

EROSION OF METAL

Erosion, or the mechanical wearing away of metal by moving water and whatever that water may carry, is accelerated by water impinging on the metal rather than merely flowing over or past it. It is distinctly advisable, in planning roof drainage, to avoid designs calling for water falling in quantities upon copper areas, such as from a dormer to a section below. Gutters and downspouts should be provided to conduct the flow on to the roof. Erosion should be considered in choosing the weight of metal at special locations.

SKYLIGHTS

The run-off from a glass skylight inhibits the formation of the natural protective coating (patina) that would normally form on copper. With an all-copper or non-ferrous skylight construction, this makes no material difference. If, however, the skylight frame is partly ferrous, iron salts washing down will cause discoloration, and possibly corrosion. To meet such a condition heavier gage metal should be used at such points, or the run-off collected in a separate gutter so that it will not drain on to the main roof area.

SEAMS AND OTHER ESSENTIALS

SOLDER, SOLDERING AND PRE-TINNING

Soldering and soldered seams should be avoided where possible. There are many instances in sheet copper work, however, where solder is necessary, and in these the joints must be tight and strong.

Success in soldering depends in great measure on the care exercised in cleaning the surfaces, for solder will not adhere to a dirty or greasy surface. Fluxes are used to remove and prevent the further formation of oxide, as solder will not adhere to an oxidized surface.

Joints to be soldered should be closely fitted together. It is a mistake to suppose an excess of solder will give a strong joint. Figure 1 plots the results of actual tensile tests. The graphs show the relation between the strength of ½" flat-lock seams and the width of the solder band showing on the finished seams. Note

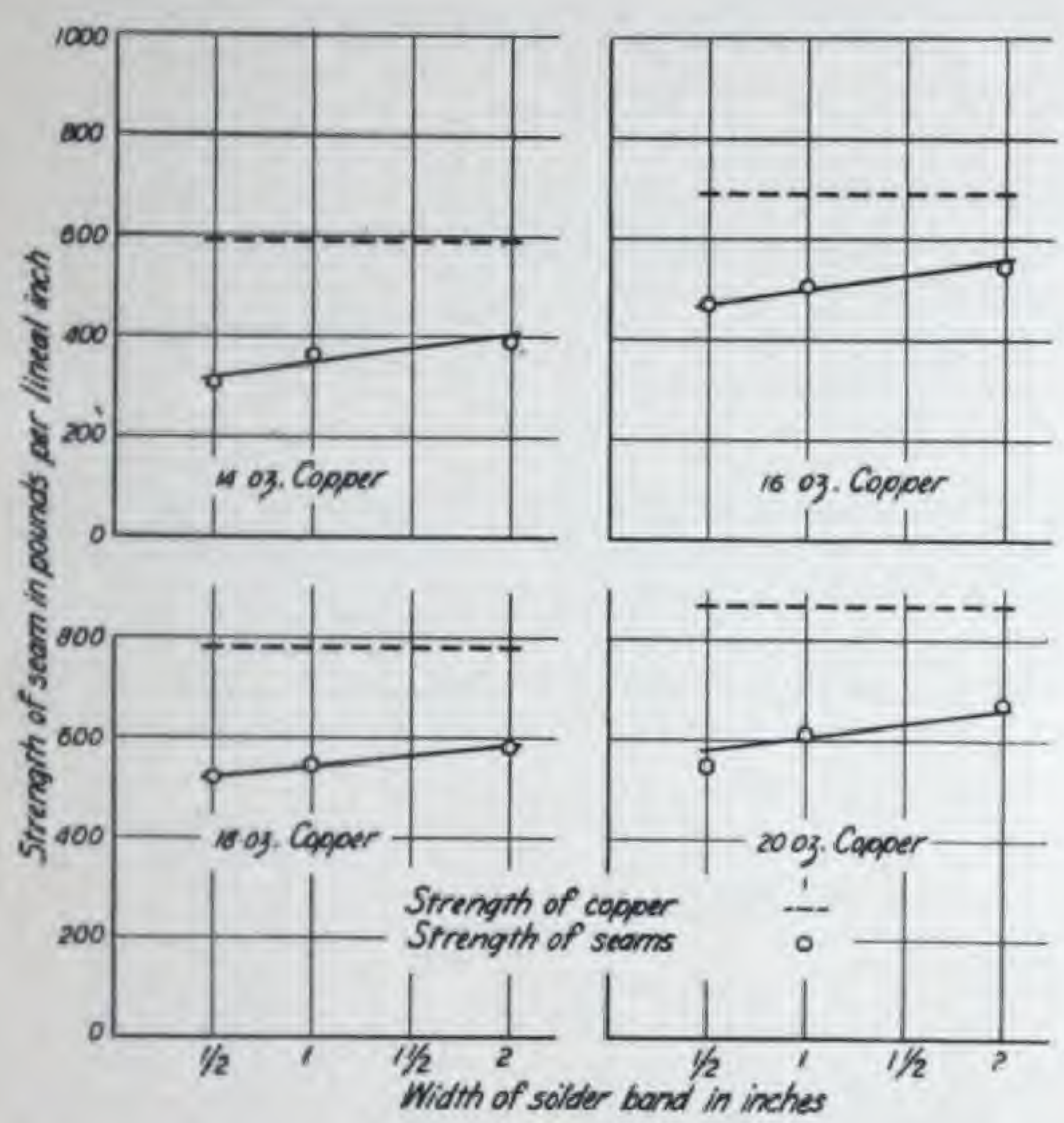


FIG. 1. EFFECT OF WIDTH (AMOUNT) OF SOLDER ON THE STRENGTH OF ONE-HALF INCH FLAT-LOCK SEAMS

Each point is an average for 24 specimens

that a large increase in the width of the solder band, corresponding to a great increase in the amount of solder used, results in only a small increase in strength. (These seams were not pre-tinned, which accounts for their strength not approaching that of the copper.) The piling up of heavy wide bands of solder on flat-lock seams to increase their strength is not worth while.

Soldering should be done slowly with properly heated coppers, so as thoroughly to heat the seam to insure a completely sweated joint. In lock seams it is most important that the seams be filled entirely with solder. In lap seams a thin film of solder with proper adhesion between the copper sheets gives a strong joint.

The edges of sheets to be soldered must be tinned on both sides before soldering, for a distance equal to twice the seam width. The value of pre-tinning is demonstrated by Fig. 2, which gives the results of tensile tests on flat-lock seams. Pre-tinning permits complete union between all the layers of copper in the seam,

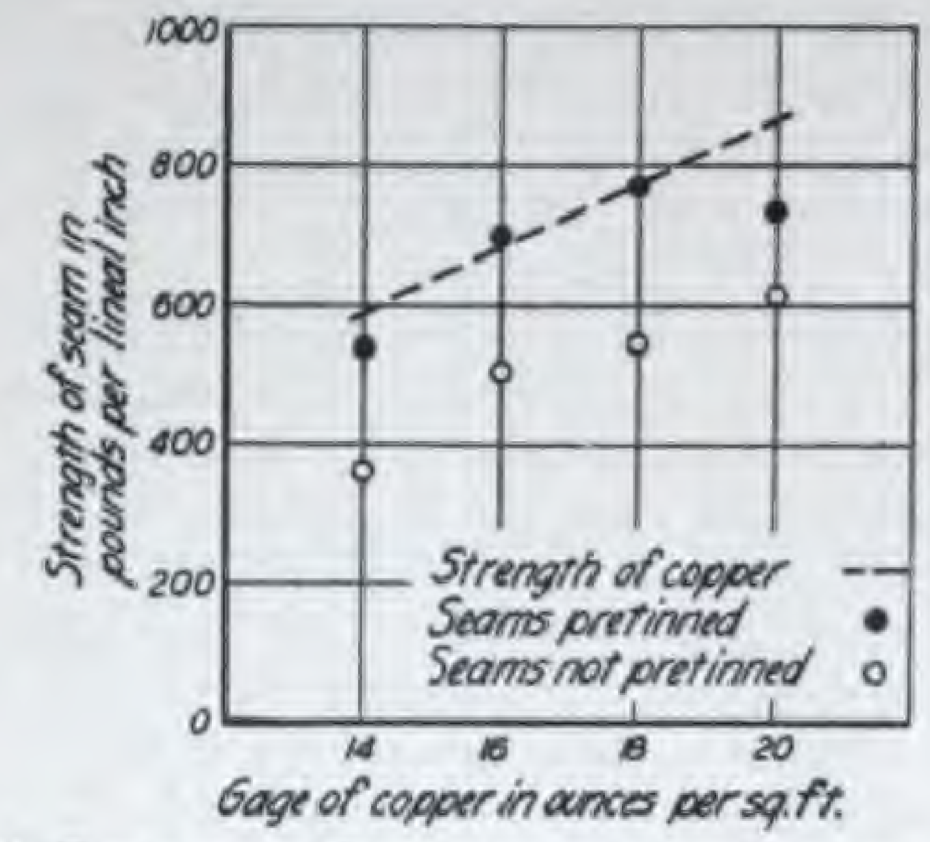


FIG. 2. EFFECT OF PRE-TINNING ON STRENGTH OF ONE-HALF INCH FLAT-LOCK SEAMS

Each point is an average for 16 specimens

whereas in the flat-lock seam made without pre-tinning only two of the layers are completely joined. (See Fig. 3.)

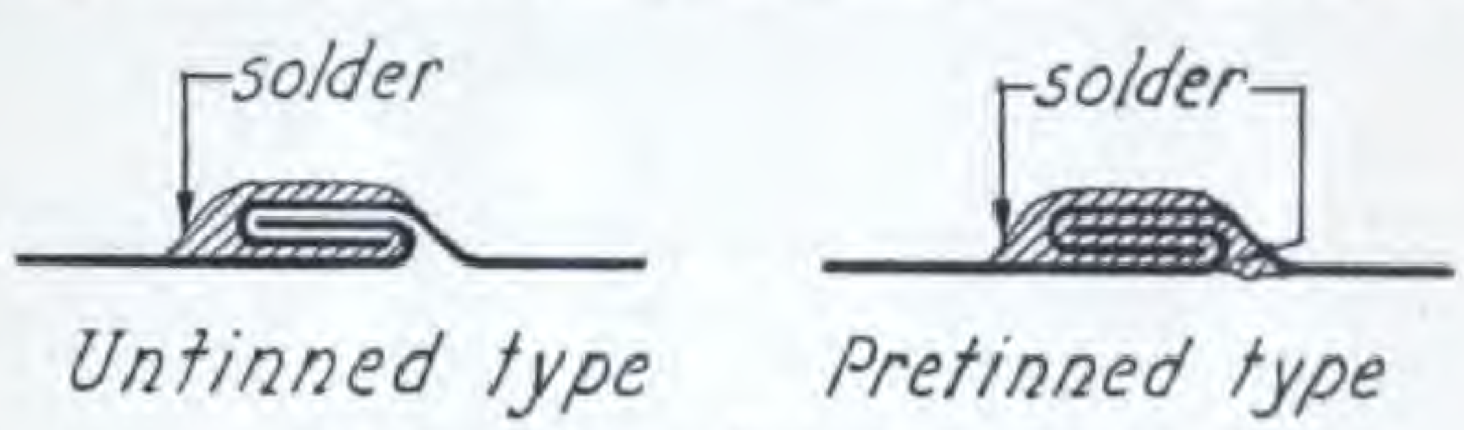


FIG. 3. SOLDERED FLAT-LOCK SEAMS

Either new block tin or "50-50" solder (half lead, half tin) should be used for pre-tinning. As is shown in Fig. 4, the pre-tinning is equally effective whether solder or tin is used. The sheets should be dipped in the molten tin or solder in the mill or the shop rather than tinned with a soldering copper on the job.

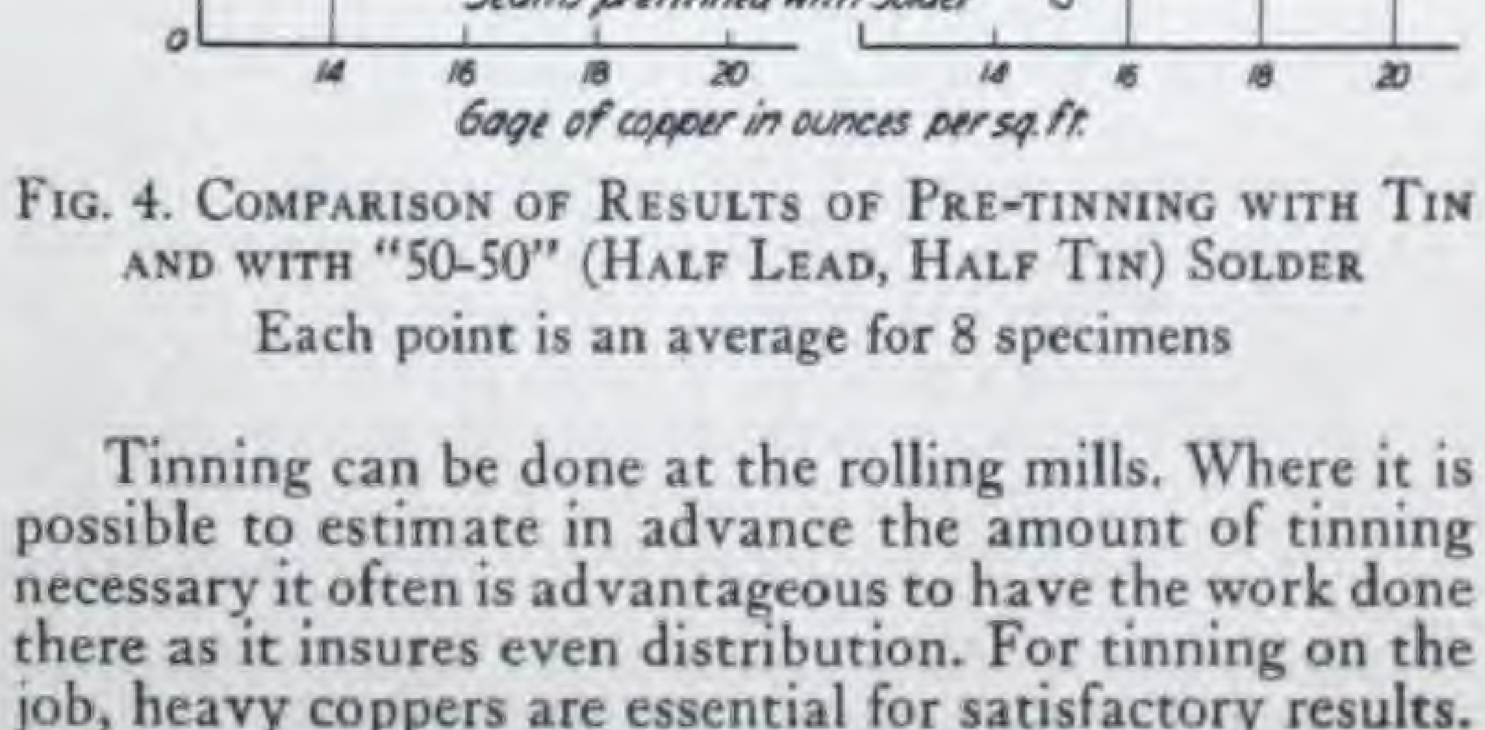


FIG. 4. COMPARISON OF RESULTS OF PRE-TINNING WITH TIN AND WITH "50-50" (HALF LEAD, HALF TIN) SOLDER

Each point is an average for 8 specimens

Tinning can be done at the rolling mills. Where it is possible to estimate in advance the amount of tinning necessary it often is advantageous to have the work done there as it insures even distribution. For tinning on the job, heavy coppers are essential for satisfactory results. The same flux is used for tinning as for soldering.

FLUXES FOR SOLDERING

Killed acid frequently is used as a flux and, in the majority of cases, successfully. Nevertheless, it should be avoided as there is danger of injury to the sheets. Should acid be used, the soldering should be washed thoroughly to remove possibility of further action by the acid which would damage the sheets or cause staining. To neutralize any acid which may be present, use a solution of soap and 5 to 10 per cent. washing soda to wash the seams and preferably over the entire job where soldering was done.

If acid is used, its proper preparation is of great importance. It is not a job to be entrusted to a novice. The acid used is hydrochloric (or muriatic). Pieces of zinc are added to the container holding the acid for the flux until, when excess zinc is added, it is not attacked; the flux is then properly killed. If this killing is done hastily or by anyone not familiar with the procedure, the acid is used in a still active state and attacks the copper. Pitting ensues and the work is spoiled. The acid to be used for an entire job should be prepared several days before the work starts and allowed to stand. Even with these precautions all work should be carefully cleaned when finished (see page 18).

Rosin is recommended as a flux. It is harmless to the metal, and, as is shown in Fig. 5, makes seams as strong as those made with acid flux. Rosin takes more labor, but it is safe. There are some objections to its use, such as sloping roofs and windy days. Under these conditions it is much easier to use killed acid. However, rosin can be kept in place by "burning" it on with a small soldering copper just hot enough to melt the rosin. Powdered rosin in gasoline can be used.

In repair work, involving weathered and perhaps dirty material, it sometimes is impossible to use a rosin flux. Unkilled hydrochloric or muriatic acid then is necessary for cleaning surfaces prior to soldering. This should be thoroughly washed off, and then rosin used as a soldering flux.

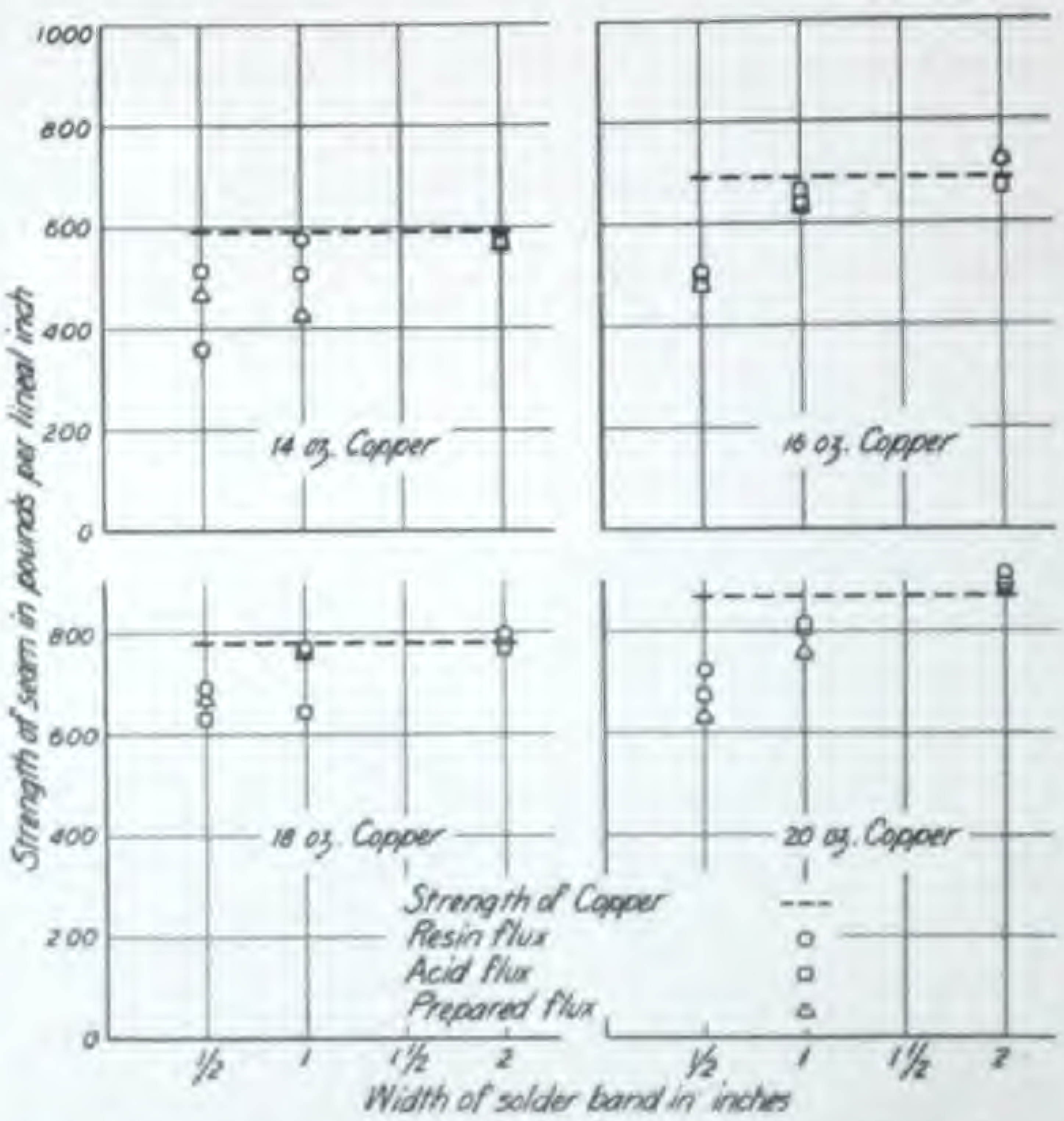


Fig. 5. Effect of Flux on Strength of One-Half Inch Flat-Lock Seams

Seams transverse to the direction of rolling of the copper. Each point is an average for 4 specimens

COPPERS FOR SOLDERING

Proper soldering coppers are essential in making tight seams. They should be of heavy, blunt-end type, to hold the heat and spread the solder. They should be moved slowly over the seam to heat the copper sheets thoroughly and to amalgamate the tinning with the solder sweated into the seam.

Soldering coppers should be tinned before use, and care must be used to avoid burning either the tinning or the copper. Soldering coppers must be hot but not overheated.

For upright seams pointed soldering coppers should not be used because there is not sufficient heat in the point. In such cases, use a flat chisel-point pattern, weighing not less than six pounds to the pair. For flat seams use a blunt square-end type of copper weighing not less than ten pounds to the pair.

COLORING OF SEAMS

Sometimes it is desirable to make seams inconspicuous by coloring the solder to match the copper. This can be done by dissolving in water copper sulphate crystals (blue vitriol) and making several applications with an iron rod or brush. Soldered seams also can be concealed by touching up with copper bronze.

THE LAP SEAM

The lap seam, illustrated in Fig. 6, is the simplest of the seams used in roofing work. It can be soldered, or in plate work can be riveted, or may be left loose to permit free movement in flashing and valley work. Where the loose lap seam is used on slopes, the amount of the lap, depending on the pitch, is important. In this connection see the discussion of valleys on page 46.

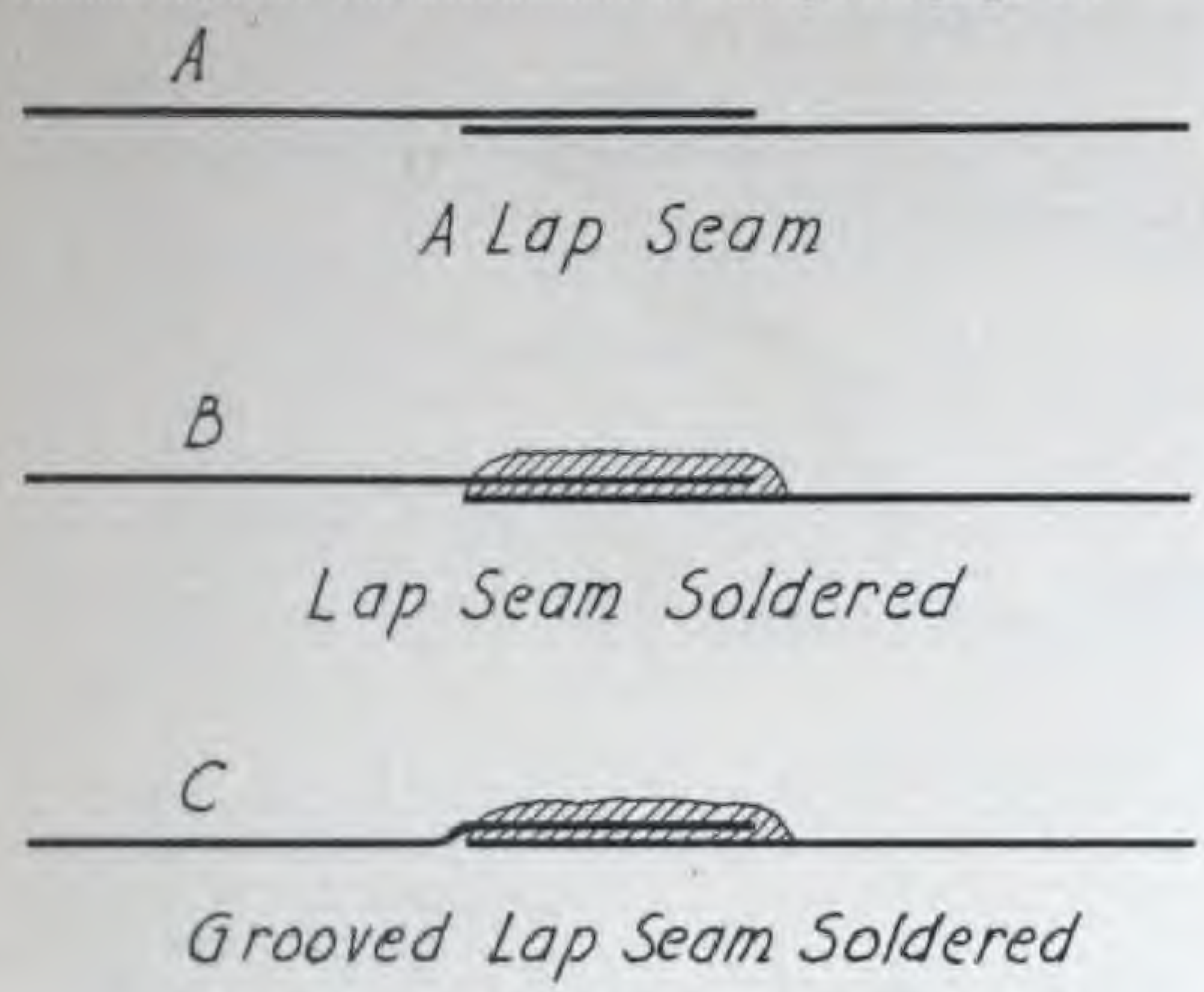


FIG. 6

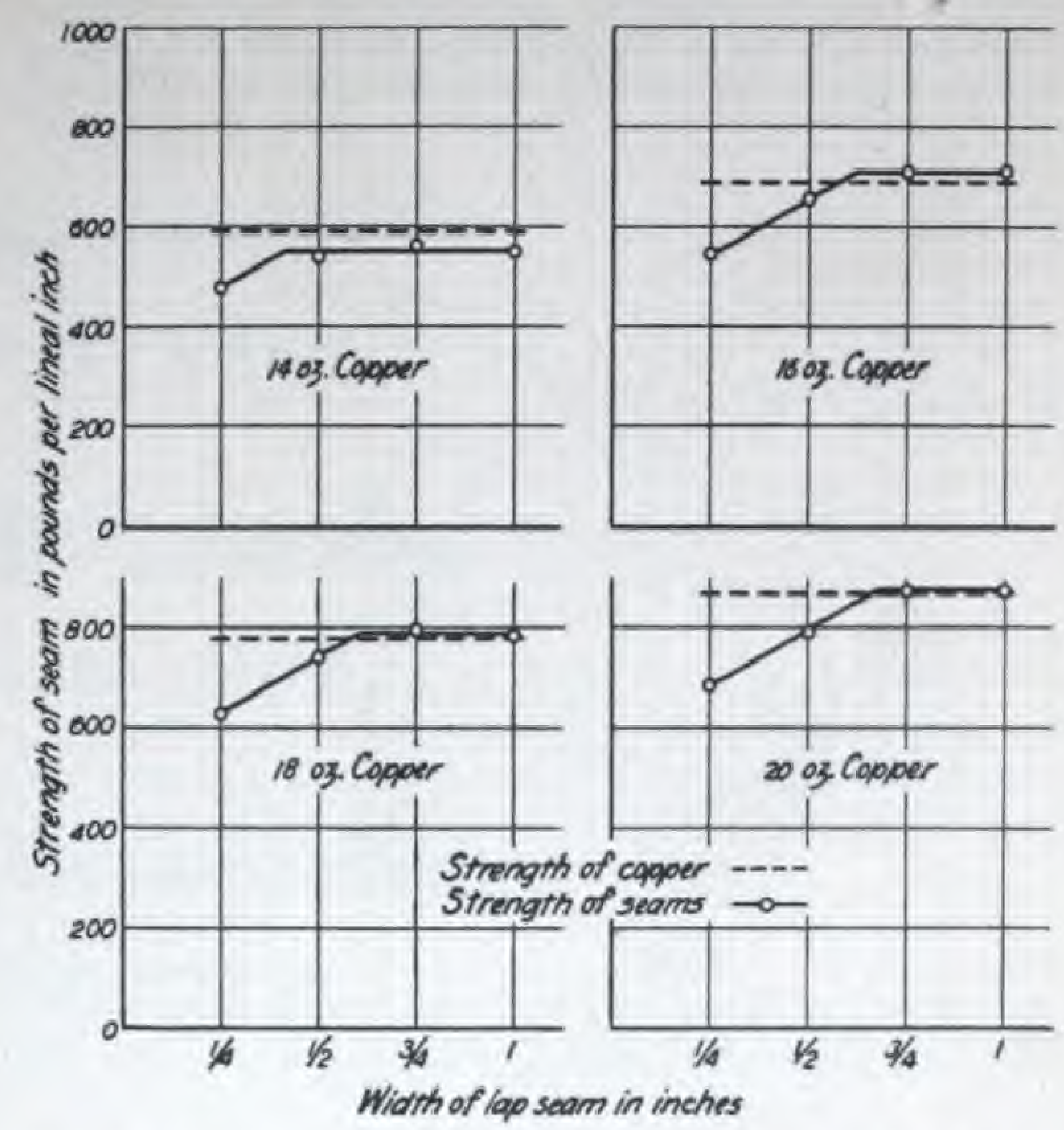


FIG. 7. EFFECT OF WIDTH OF LAP ON STRENGTH OF LAP SEAMS
Each point is an average for 24 specimens

Usually lap seams to be soldered are made one inch wide, with the edges of the sheets pre-tinned 1½ inches. Fig. 7 shows the results of tensile tests on soldered lap seams, and it is evident that where stresses are to occur in the sheets, a lap seam of less than three-quarters of an inch will not be satisfactory under any circumstances. Where there is assurance of no strain on the seam a half-inch lap should be sufficient, but in most cases the lap should be made one inch. Tests under prolonged loading were also made, and the results are shown by the graph in Fig. 8. The indications are that the maximum stress which lap seams will withstand indefinitely is in

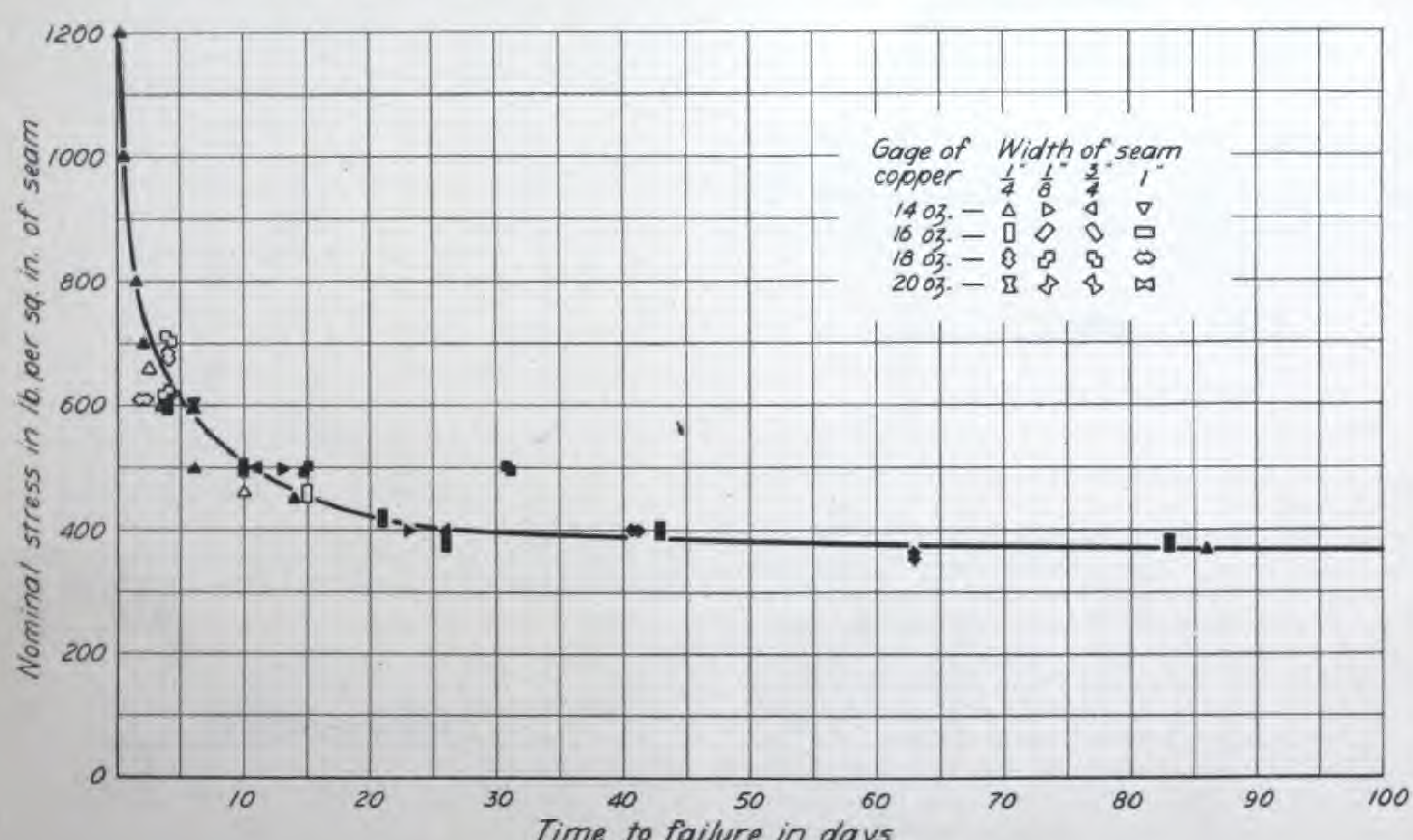


FIG 8. RESULTS OF PROLONGED LOADING TESTS ON LAP SEAMS

the neighborhood of 350 lbs. per sq. in. of seam. If this figure is used to compute the width of seam required when the load to be carried is known, allow a liberal factor of safety for possible imperfections in soldering.

Riveted lap seams are illustrated in Fig. 9. This type is used mainly for plate work, although occasionally roofing accessories such as tanks, cornices, skylights, etc., require this type of seam for sheet copper.

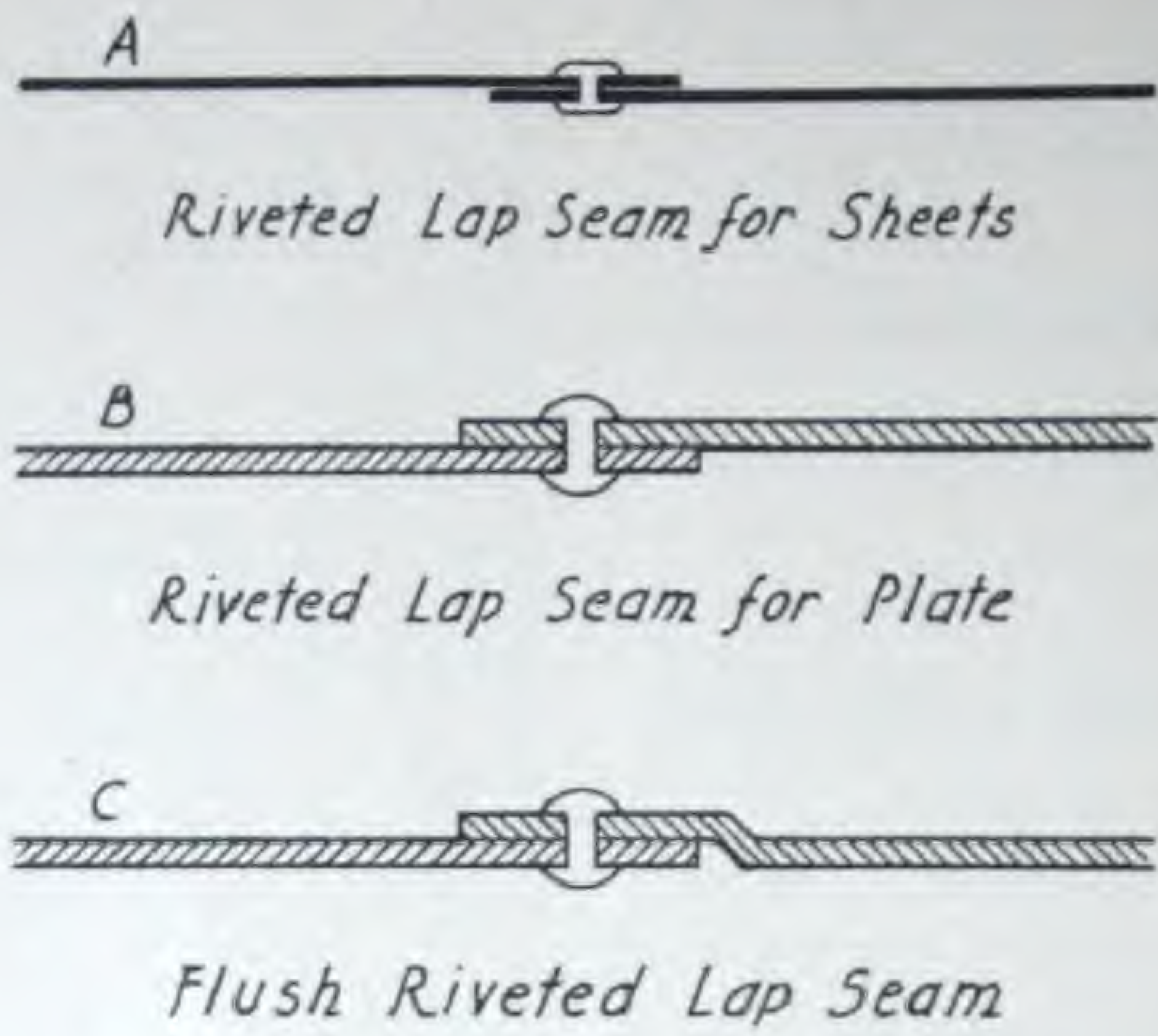


Fig. 9

HOOK OR FLAT-LOCK SEAM

The hook seam is the type most widely used in copper work, and is illustrated in Fig. 10. It is made by turning the edges of adjoining sheets in opposite directions, hooking them together, and dressing down the joint with a mallet. The flat-lock seam (sometimes called the groove-lock seam) of roofing parlance, is a slight variation of the hook seam, as shown in Fig. 11.

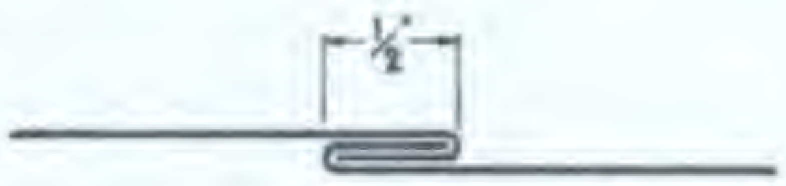


Fig. 10. A Common Lock or Hook Seam

Fig. 11. A Flat-Lock Seam

It can be developed from the hook seam by the use of a grooving iron.

It is often necessary, however, to make flat-lock seams where there is not sufficient room to hook the sheets together. The seam then is developed as shown in Fig. 12, as follows: (1) Tin the edges of the sheets, (2) Bend the edges at right angles, (3) Set the sheet with the short bend in place, (4) Set the second sheet in position and, (5) Turn the edge of the second sheet 180° down over the edge of the first sheet. Finally, (6) Turn all together 90° in the same direction down on the first sheet, flatten and solder. When the seam is to be cleated down, an additional step is required between (3) and (4) above, namely, (3a) Place the cleat against the sheet and nail the cleat to the roof, turning the end back over

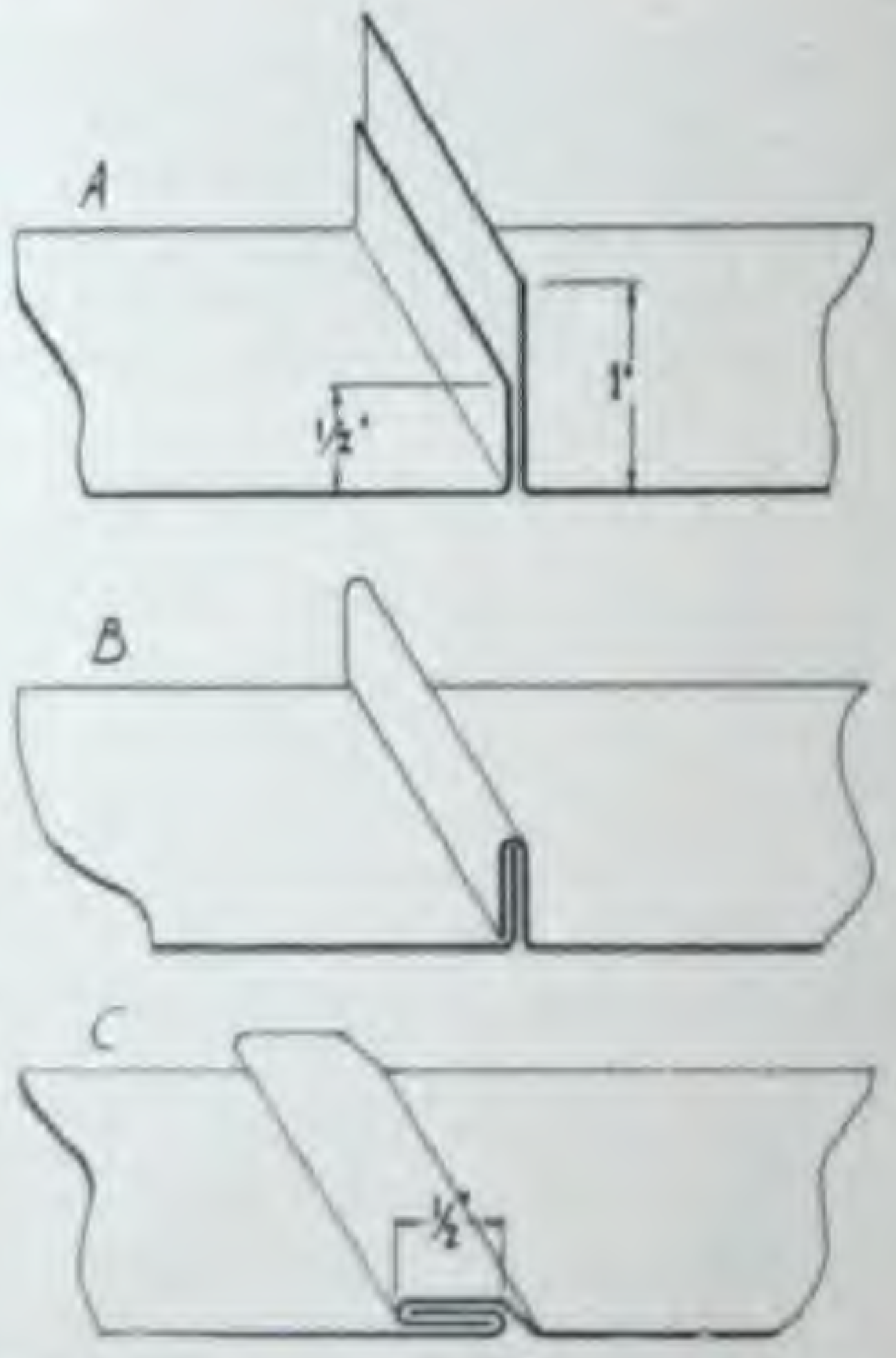


Fig. 12. Development of a Flat-Lock Seam

the nails. The cleat then is folded in with the sheets. Figure 13 shows a single flat-lock seam with cleat.

Fig. 13. A Flat-Lock Seam and Cleat

It is essential to a good job when soldering flat-lock seams that the solder be well sweated in so as to fill the

lock completely. Figure 14 illustrates both the correct and incorrect methods of flat-seam soldering.

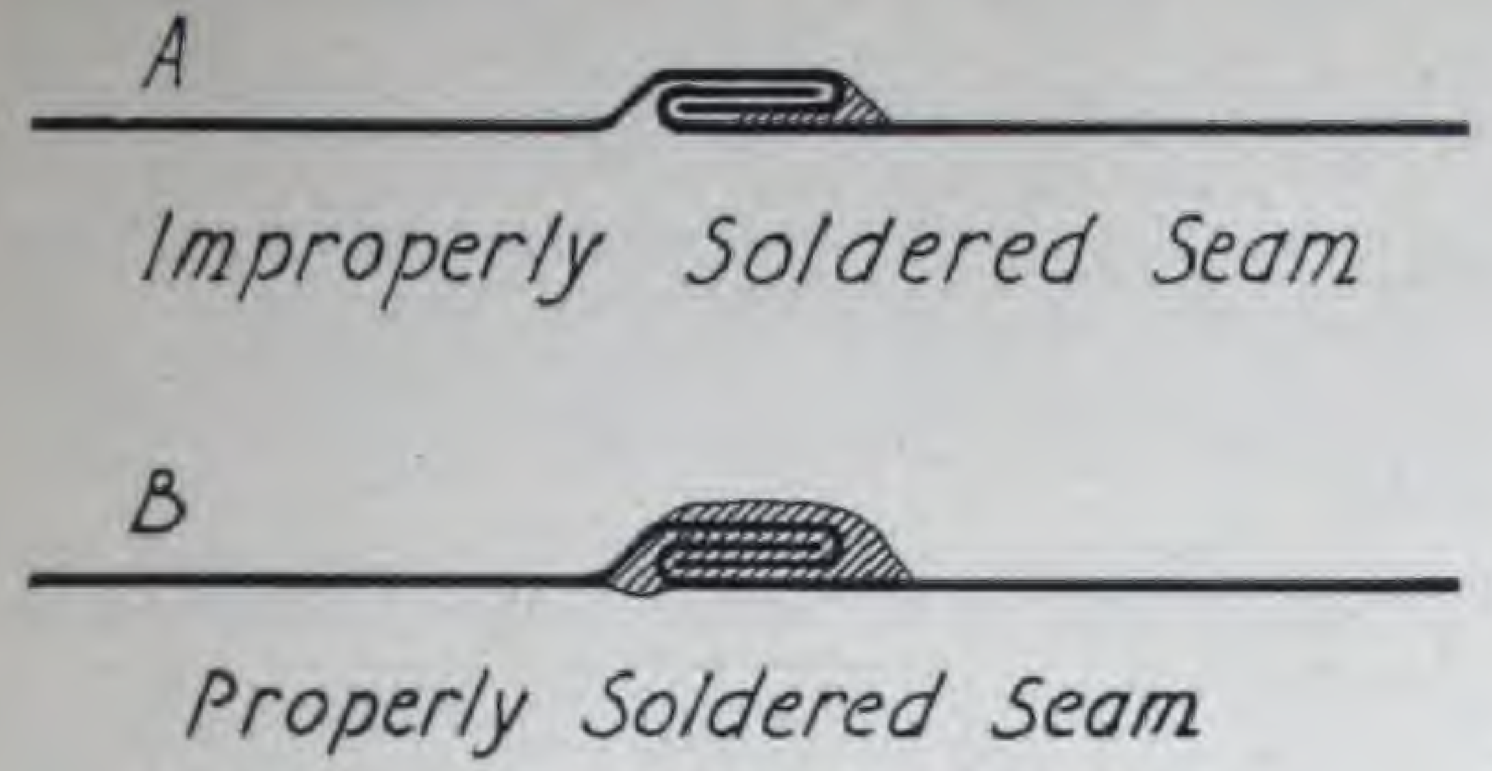


Fig. 14

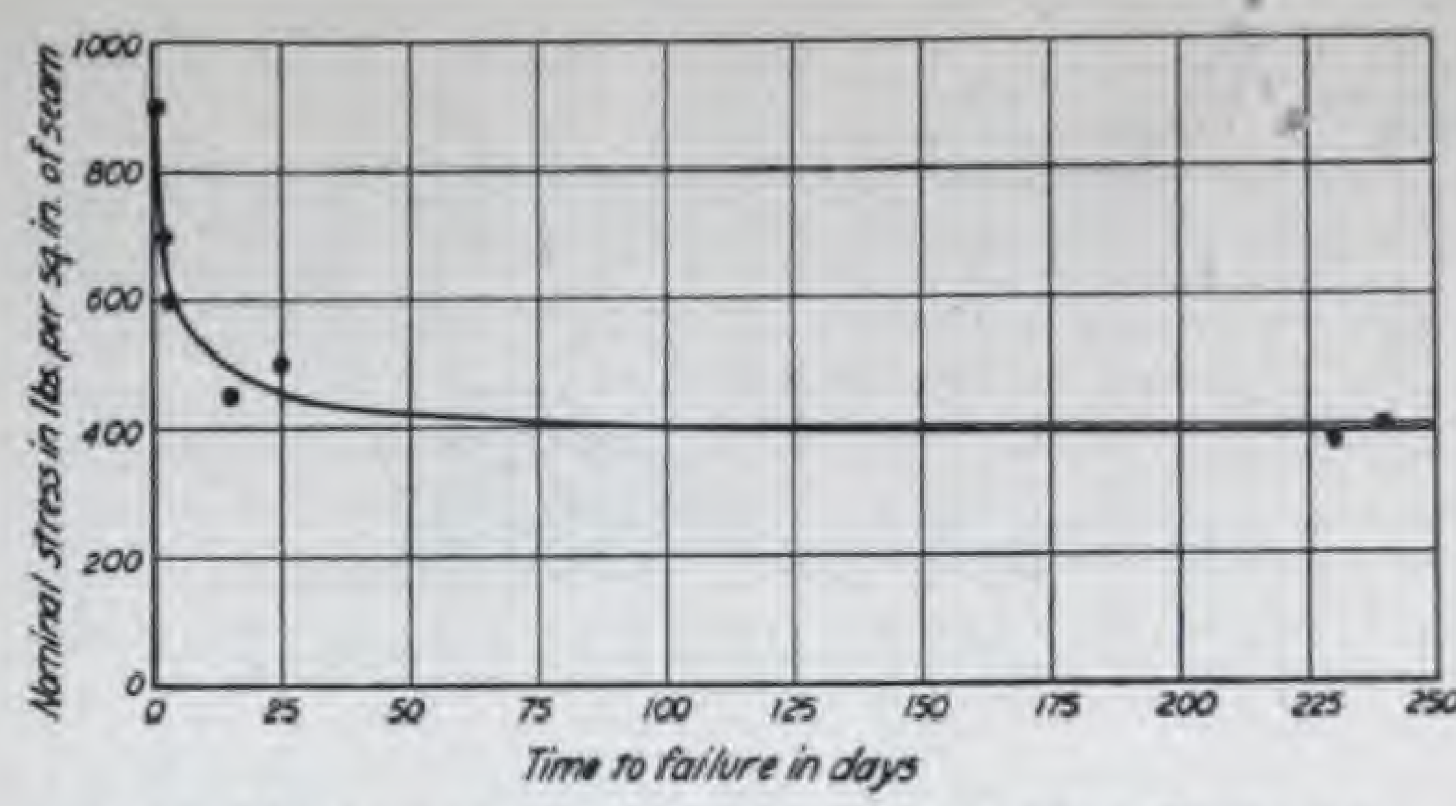


Fig. 15. Results of Prolonged Loading Tests on Pre-tinned One-Half-Inch Flat-Lock Seams on 16-Ounce Copper

Flat-lock seams in 16-oz. copper should be at least ½-inch finished. Prolonged loading tests made on pre-tinned ½-inch flat-lock seams, as shown in Fig. 15, indicate the maximum stress this type of seam will withstand indefinitely is about 375 lbs. per sq. in. of seam. It can be assumed that these results will hold for seams up to 1 inch, at least; however, a liberal factor of safety to care for variations in workmanship should be employed in design computations.

THE STANDING SEAM

The standing seam is widely used as the longitudinal seam between the long dimensions of sheets in the direction of the slope in copper roofs. It gives an attractive and interesting ribbed appearance and also, being unsoldered, allows for expansion and contraction. This seam, too, sometimes is used as an expansion joint at the high point of a deck or flat roof.

The standing seam is literally a double-lock standing seam and is illustrated in Fig. 16. It is developed as follows (see Fig. 17): (1) Bend the edges of the sheets at right angles, 1¼ inches on one edge and 1½ inches on the other edge. Then, (2) two sheets are placed together on the roof with the 1¼-inch face of one against the 1½-inch face of the other. (3) The projecting ¼ inch of the 1½-inch face is turned completely back 180° on the 1¼-inch face of the other. (4) The two sheets thus joined are then turned again 90°, and (5) finally again 90°, and the folds pressed tightly together. The seam thus formed finishes one inch high.

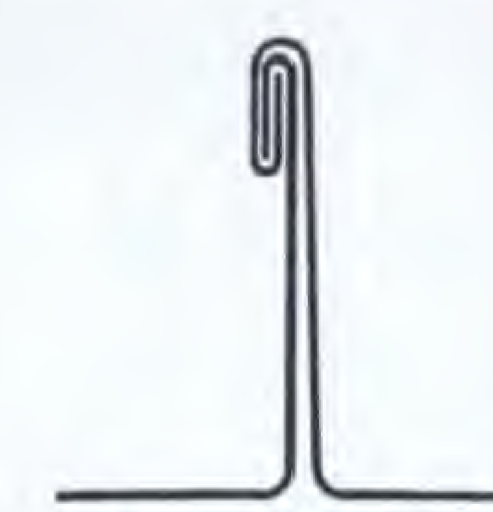


Fig. 16. A Standing Seam

A ¾-inch finished standing seam is made by turning the edges 1 and 1¼ inches.

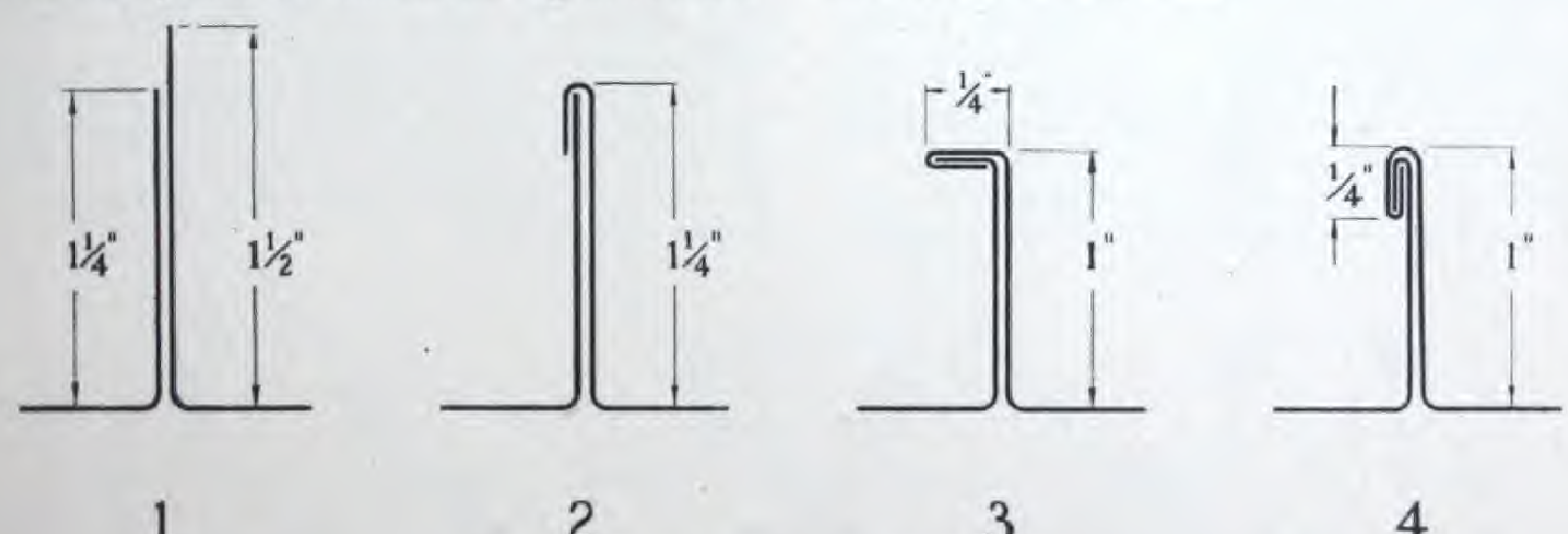


Fig. 17. Development of a Standing Seam

LOOSE-LOCK SEAMS

It frequently is necessary to provide for expansion where usual methods do not apply. This is particularly so at the intersection of different roof planes and at the top of built-in gutters. At these locations a loose-lock seam is recommended. This consists of a hook-lock, a standing seam bent flat, or a loose double-lock, and is left unsoldered. It acts as an expansion joint. Care must be taken to place the lock, which is not water-tight, so that it will not leak. It also should be placed as close as possible to the line of intersection.

Frequently it is necessary for the loose-lock seam to be held in place with cleats. In box-gutters where the roofing sheet is secured on the roof no cleat is necessary. As such a seam is not water-tight it must be located above the outside edge of the gutter, or above the scupper level if behind a parapet wall.

THE DOUBLE-LOCK SEAM

The double or copper-lock seam, shown in Fig. 18, is used to avoid soldering or to allow for expansion and

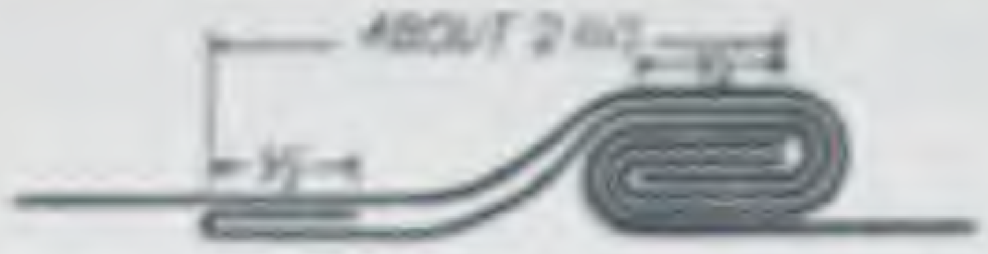


Fig. 18. A Double-Lock Seam with Cleat

contraction. One of the two methods of making this seam is shown in Fig. 19. This requires slipping the sheets together from the side after each has been folded as shown in Drawing 2 of Fig. 19. If this is located so that the sheets cannot be slid together, it is made as follows, which virtually is a standing seam bent flat: (1) Bend the edges of the sheets at right angles, one edge 1 inch, the other 1½ inches, (2) Place the sheets together, a 1-inch edge against a 1½-inch edge. (3) Turn the 1½-inch edge 180° down on the 1-inch edge, (4) Turn both together again, in the same direction, another 180° and finally, (5) Turn both in the same direction 90° down on the roof sheet, mallet together and, on flat roof work, tip the outer edge with solder.

The double-lock seam uses more copper than the single lock, 2½" being needed instead of 1½". This amounts to about 7% of a 24" x 30" sheet.

To prevent water entering under the unsoldered edge, freezing and opening the seam, the seams should be made with the slope and on flat surfaces tipped with solder on the outer edge.

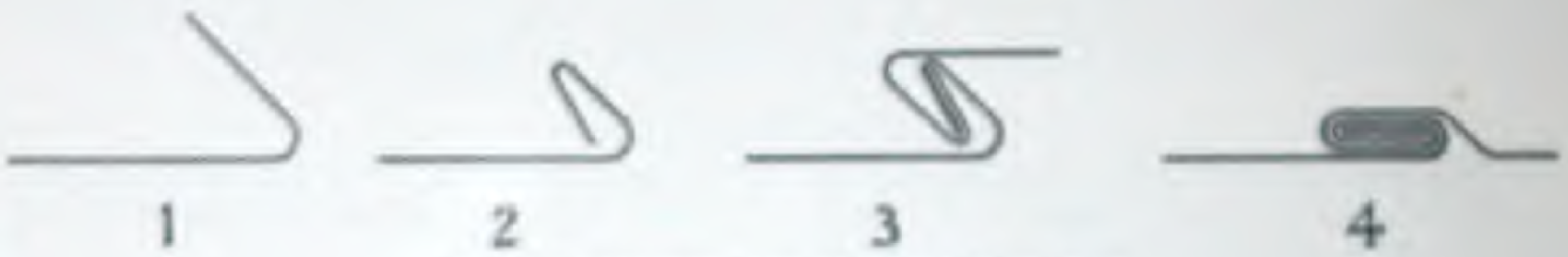


Fig. 19. Development of a Double-Lock Seam

BATTEN OR RIBBED SEAMS

The ribbed, or batten, seam is widely used for sheet copper roofing, and is highly satisfactory as it allows ample provision, if properly carried out, for expansion and contraction. This type of seam is discussed further under "Batten Seam Roofing", beginning on page 23. The copper sheets are formed over ribs or battens running down the roof slope. Various designs are possible for the battens, which ordinarily are of wood but may be of metal. The methods of forming the seams may vary according to the design adopted. Several common types of wood battens are shown in Fig. 20.

The primary purpose of batten construction is, of course, to break up the long run of a roof into a number of smaller areas, so that the space required for movement of the metal at any one point will be small. Any design that accomplishes this purpose is acceptable, but we recommend battens such as Types A, B and C, which use a separate batten cover, in preference to battens that are covered by part of the roof sheet, as in Types D, E and F. The first group of types permit freer longitudinal movement of the sheets.

In any case sharp bends of the copper at the heel of the batten should be avoided, and clearance should be provided at that point for movement of the sheet. For the sake of clarity in subsequent drawings we have shown only Type A.

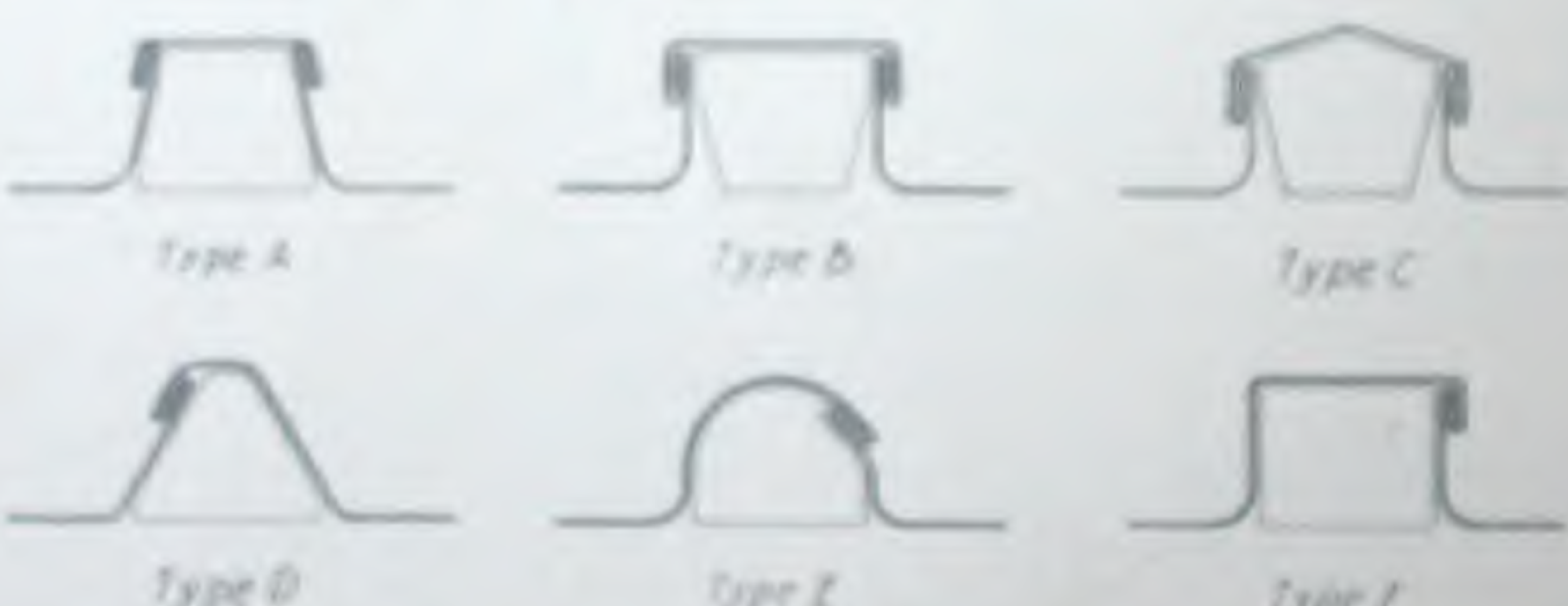


Fig. 20. Wood Battens

SEAMS IN CAP AND BASE FLASHINGS

Cap flashings are usually made from 8-foot strips, the standard maximum length for copper sheets. Best practice permits adjacent sheets to be merely lapped about three inches or to be formed into a flat lock. In either case solder is usually omitted.

In base flashings, on the other hand, the seams are of the flat-lock type illustrated in Fig. 11. They will be about eight feet apart and should be spaced so that they do not occur with the seams of the cap flashing. They are made as is usual in flat seam construction and should be folded in the direction of the flow. The ends of the sheets are tinned and the lock sweated full of solder. The sheets being in a vertical position, special care must be taken in the soldering so the seam is filled. Flat-type soldering coppers only should be used here, as pointed coppers do not have sufficient heat to soak the seam thoroughly with solder. If the flashing extends over 30 feet, provision must be made for expansion.

MISCELLANEOUS SEAMS AND JOINTS

Combinations of batten and standing seam principles are illustrated in Fig. 21. Their construction is self-evident. They have no wide use in roofing or flash-

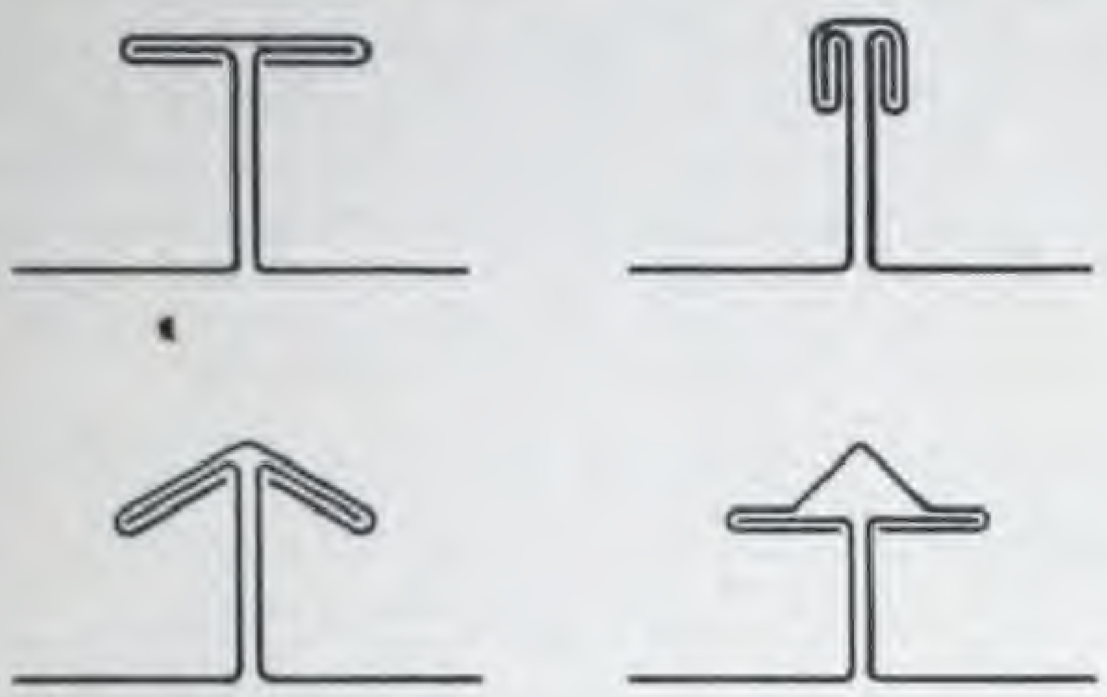


Fig. 21. Miscellaneous Seams

ing, but have a place occasionally as expansion joints, as in large flat decks, or for ornamental purposes.

Free movement of copper is essential at all times. Such movement is restricted when sheets pass over angles as sharp as 90°. Accordingly, where copper sheets must be carried over such an angle for more than a few inches, locks should be inserted at the angles as suggested in Fig. 22. The double seam at the right is more secure and forms a drip edge, and is, therefore, more generally satisfactory.

Edge stiffeners are shown in Fig. 23. This practice of folding all exposed or loose edges of flashings back on themselves ½ inch is recommended, as it stiffens the edge and prevents lifting by the wind and clogging with snow and ice. It also makes a neat finish. The

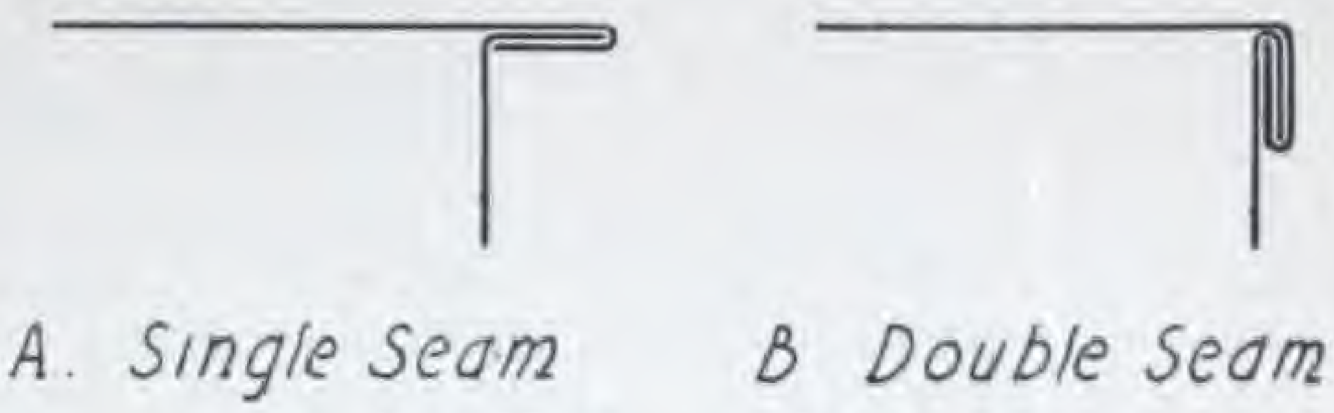


Fig. 22. Corner Locks

edges are flattened tightly together after the 180° fold.

Varieties of loose-lock seams for use as joints on roof slopes and valley connections are shown in Fig. 24. Figure 24A is merely the flat-lock seam already described. Figure 24B shows a variation of this seam

Fig. 23. Edge Stiffeners

where the bottom hook is wider. This gives additional head lap (*i.e.*, vertical distance between the lowest point of the top sheet and the highest point of the bottom sheet), and also reduces the danger of leakage from capillary action should the loose-lock fill with water.

The construction in Fig. 24C carries this principle further, to any desired degree. Here the upper sheet is locked into an auxiliary strip previously soldered across the entire width of the lower sheet. Desired head lap can be obtained by varying the location of this strip. The upper edge of the bottom sheet is turned back as a hook for cleating. In the other two methods the cleats are locked into the seam.

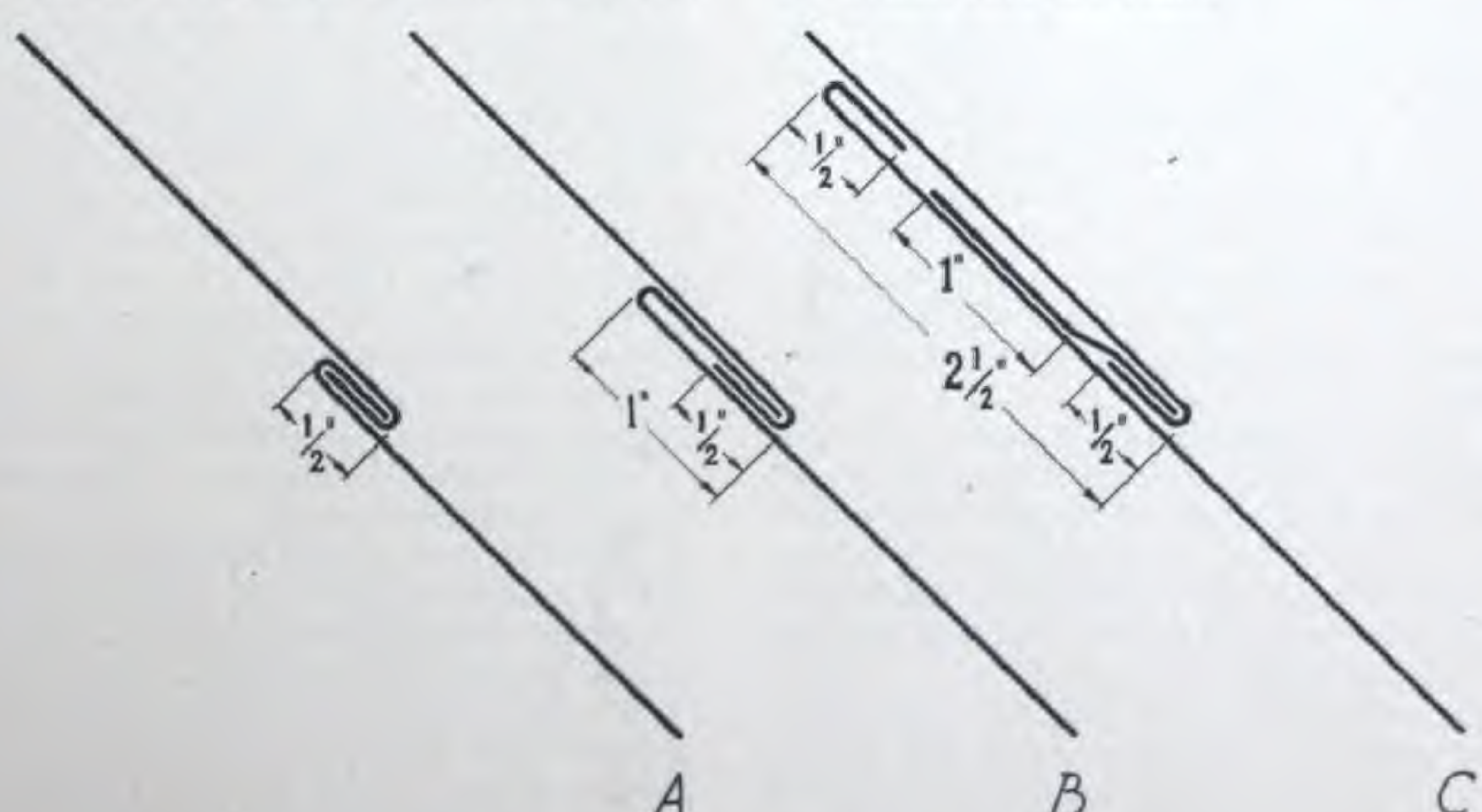


Fig. 24. Loose-Lock Seams

BENDS IN COPPER

Sharp bends in copper sheets should be avoided, and in all work the material should be creased, worked, or bent as little as possible before laying. It also is important in forming seams to avoid cuts, breaks and cracks at the fold; while completed seams should be well malleted, hammering should be avoided.

At all changes of direction or of planes of roofs, as where a dormer roof meets the main roof, or the bottom of a built-in gutter turns up to meet the sides, special precaution must be taken to avoid breaks and cracks. Where copper sheets are confined in sharp angles there is a restraint of free movement and the copper warps and buckles. The sheet loses its ductility and fracture may result in time, for the free "flowing" of the sheet is prevented and a place for a buckle to start is provided.

This can be avoided by using small blocks in corners and working the sheet over them in a gradual or easement curve.

NOTCHING SHEETS FOR FOLDING

It often is necessary to form a lock-seam between copper sheets which pass over angles 90° or sharper. Under such conditions the metal crimps together if the sheets are folded over the corner before the seam is completed. Wherever possible the sheets should be locked together first. If this is impossible, the copper may have to be cut out at the angle to permit completing the lock. Such cuts should not be slits or notches, but should be in the form of semi-circles extending only half-way to the fold. Deep notches may start fractures.

EXPANSION JOINTS

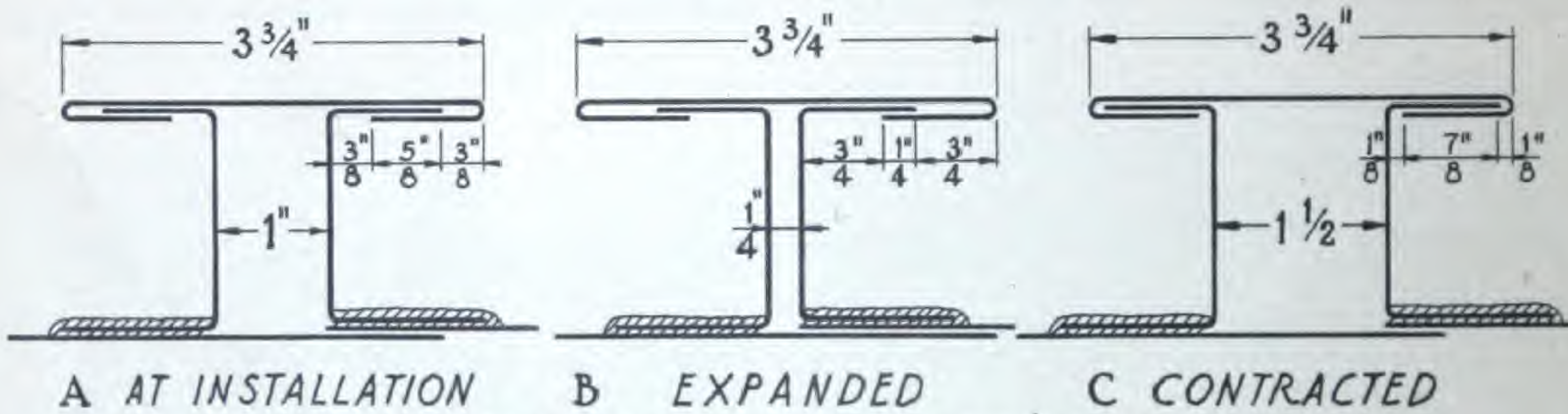


FIG. 25. CROSS-SECTIONS OF AN EXPANSION JOINT

The problem of expansion and contraction really is one of comparative, or relative movement, since all materials do not increase or decrease in length by the same amount for the same change in temperature. Copper has a higher coefficient of expansion than most building materials and hence tends to move with reference to the main structure or the parts to which it is attached. If sufficient allowance is not made in the design, the metal necessarily will have to buckle or tear. The temperature when the copper is laid will determine whether provision must be made for expansion or contraction, or both.

Movement due to temperature changes can most often be cared for in roofing and flashing work by the nature of the construction itself, as for instance, standing and batten seam roofing, cap and base flashings, the use of small sheets for flat roofs, etc. Additional expansion and contraction details are described in the later discussion of installation features.

Large steel-framed structures sometimes are built with expansion joints to allow for movement in the frame. Where copper-lined gutters, or cornices, etc., are used with this type of structure it is necessary to provide expansion joints at the points where they occur in the building. These are shown in Fig. 25. The gutter-linings are turned up at right angles to and slightly higher than the depth of the gutter, the ends bent 90° to the vertical, and a cap locked over the top. The joint should allow a small space between the vertical sides when the gutter-lining is fully expanded, and the length of the flanges and width of the cap calculated to care for the full contraction of the metal. The top of the joint should be higher than the elevation of the outside edge of the gutter so water cannot enter under the loose cap in case of outlet stoppage.

This type of joint should be placed at the high point of large built-in gutters when gutter lining is not made of small sheets cleated down. They should be spaced from 30 to 40 feet apart.

Usually such a gutter-lining is locked to the roof covering and cornice strip with watertight joints. It sometimes is considered doubtful if the force of expansion and contraction will overcome completely the frictional resistance of such locks so that the whole amount of movement can evidence itself at the expansion joint. However, with gutter and other copper work properly installed satisfactory results have been obtained with this type of joint.

In roofing, expansion is, of course, a function of the linear dimensions only. The weight or gage of the metal does not enter into the calculation. For example, the procedure in calculating the allowance needed for expansion and contraction is shown below. This calculation is for a 70-foot copper box gutter, assuming the ends fixed and that it is laid in 65° weather in a locality whose maximum temperature range is 0° to 100° F.

Data: Coefficient of linear expansion of copper = .0000095 per degree F.

To simplify the calculation call this .00001

Minimum design temperature = 0°F.

Maximum design temperature = 100 + 50 superheat (see page 6) = 150° F.

Contraction temperature difference = 65 − 0 = 65°

Expansion temperature difference = 150 − 65 = 85°

Amount of contraction = 70 x .00001 x 65 = .0455′ = .54″, say ½″

Amount of expansion = 70 x .00001 x 85 = .0595′ = .71″, say ¾″

Allowing ¼-inch clearance with heads expanded,

Clearance of heads at installation = ¼ + ¾ = 1 inch

Clearance of heads when contracted = 1 + ½ = 1½ inches

Total relative movement of heads = ½ + ¾ = 1¼ inches

Movement of each head = ⅝ inch

Allowing ¼-inch laps with cap at top angles when expanded, and ⅛-inch clearances when contracted.

Leg of each top angle = ¼ + ⅛ + ⅝ = 1 inch

Fold-back of cap also = 1 inch

Total width of cap = ¼ + 4 x ⅛ (clearances) + 1¼ (total movement) + 1¾ (two laps) = 3¾ inches

Or Total width of cap = ⅛ + ⅛ (two clearances) + 2 (angle legs) + 1½ (clearance) = 3¾ inches

BUILT-IN GUTTERS

Built-in gutters to be lined with copper can be handled by two methods, the first using long sheets (4′ or 8′) continuously soldered together, and the second using small sheets (14″ x 20″) cleated down as in flat seam roofing. The choice depends on the gutter design.

In the first method, the lining is installed as a "floating unit", and must be left free to move at all extremities. In runs longer than 30 feet expansion joints should be provided at high points as described under the previous heading. The construction is described on page 68. For this method the design should be such that the lining can be free to move as a unit.

A preferable method, under some conditions, is the use of small sheets with seams staggered. The large number of seams tend to stiffen the copper and prevent buckles. The lining should fit loosely and all sheets should be secured by cleats. In this way the movement is confined by the cleats and is not multiplied throughout the gutter length. There is enough leeway at the cleats to take up the small amount of movement in a single sheet. However, expansion joints are required 30 feet apart as in flat seam roofing. (See page 34).

Built-in gutter design should provide a loose-lock seam between the roof slope and the gutter lining at a point higher than the maximum water-level, which generally is determined by the outside edge of the gutter. The outside edge of the lining should not be caulked into a reglet but locked to a strip fastened into the reglet. Further information on gutters appears on pages 64 to 78 inclusive.

WHITE-LEADED SEAMS

To permit freedom of movement through temperature changes, the use of loose-lock seams wherever possible is recommended. When such a seam is located so a head of water cannot reach it, no treatment of the seam is necessary. In many instances, however, water flows by or over a seam, and yet cannot back up to form an appreciable head. In such cases the loose-lock seam should be caulked with white lead paste.

This gives a highly satisfactory seam, which will not leak under four inches of water; and the white lead paste will allow a certain degree of movement which would be impossible if the seam were soldered. The use of white lead in seams is not new, an outstanding example being the roof of the State House in Boston.

The recommended white lead paste is that composed of basic lead carbonate and boiled linseed oil. The oil should make up 8% of the mixture. The paste must be smooth and of putty-like consistency. Lumps will make uneven seams and prevent the locks from being filled completely.

Actual tests have shown that flat-lock seams caulked with white lead will not leak under water up to four inches deep. Such seams are cheaper than soldered seams, and the use of white lead also aids in concealing them. The white lead paste is smeared generously onto the edges of the sheets and is folded directly into the lock as the seam is formed. All excess lead should be removed from the sheets.

FASTENINGS FOR COPPER WORK

Proper fastenings are fundamental in installing copper work, and these definite rules should be followed:

I. All fastenings for copper should be of copper or a copper alloy.

II. Never secure copper in any way which will prevent some free movement.

III. All small pieces of copper, regardless of size, forming part of a roof, gutter, or other large unit, should be cleated. Do not nail.

IV. Fasten copper flashings more than 12 inches wide with cleats. Do not nail.

Rule I merely is an application of the principle that dissimilar metals must never be in contact. This applies not only to nails but to hangers, brackets, and braces, and to screws and rivets. When other metals, particularly steel or iron, are used, a galvanic action takes place between the copper and the other metal which soon destroys the latter.

Rules II, III, and IV pertain to the fundamental that provision must be made for expansion and contraction. The use of cleats permits such movement, and also restricts it to each sheet so the movement is not multiplied throughout the entire copper work.

Flashings less than 12 inches wide may be secured by nails, with spacing varying for different types of flashing. In such instances the nailing should be restricted to one edge only. Nails should be near the edge and evenly spaced, not more than four inches apart.

The greatest source of flashing trouble comes from failure to observe Rules II and IV in valley flashings. These, by their very nature, usually are from 16 to 24 inches wide, and must be secured on both sides. Figure 26 shows a valley flashing. If such a flashing is nailed, two things may result from movement through extreme temperature ranges: the flashing tears at the nails and becomes loose, or the sheet buckles along the edge of the roofing material. With the first, water works under the loose flashing; with the second, splitting or cracking occurs from fatigue of the metal.

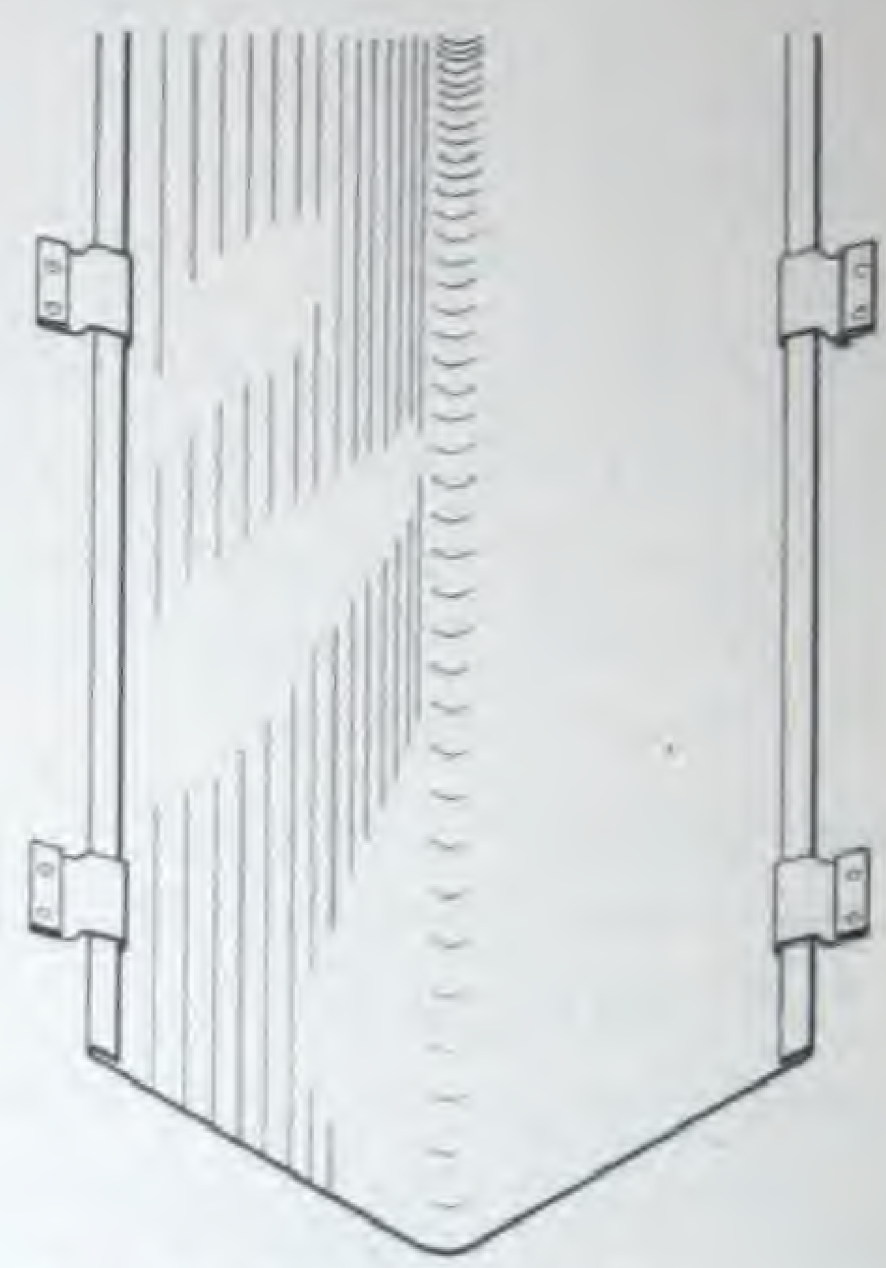


FIG. 26. OPEN VALLEY FLASHING

This trouble is avoided by securing flashings with cleats. The cleats are nailed, it is true, but Rule II is observed. The sheet, not being fast, moves freely and the cleats take up the movement.

CLEATS FOR COPPER WORK

Cleats should be made of 16-oz. soft (*R. T.*) copper, not less than 1½ inches wide, and should be fastened with two copper or copper alloy nails as shown in Fig. 27. A width of two inches is preferable, as it gives a stronger cleat and removes possibility of the nails tearing out. The nails should be placed in line parallel to the edge of the sheet to keep the cleat from turning. The end of the cleat must be bent back over the nails to prevent the nail heads from cutting the sheet.

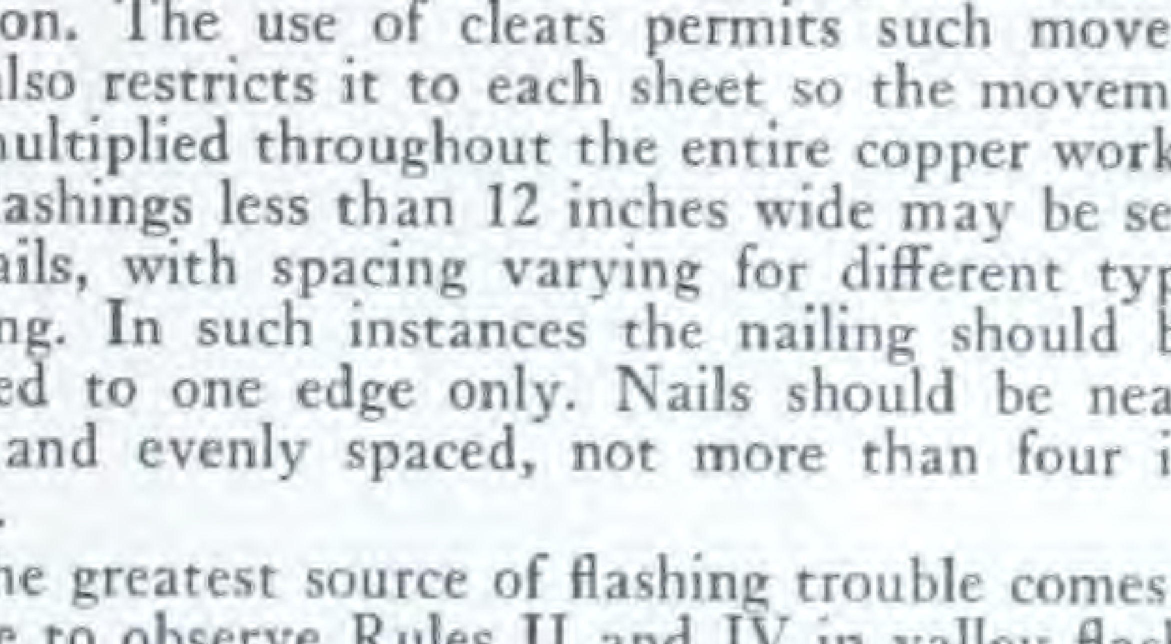


FIG. 27. A COPPER CLEAT

The length of the cleat is determined by the kind of seam with which it is used.

The maximum spacing of cleats should not exceed 12 inches; a spacing of six or eight inches is recommended. This does not apply to concealed valley flashings, etc., where the sheet or strip is held by the roof covering. Under these conditions the spacing may be increased considerably; a maximum of 24 inches is recommended.

The cleat holds the copper sheet as shown in Fig. 27. If it also secures a second sheet, it is folded in with the sheets as the seam is formed. In such cases the cleat must be nailed down before the sheets are brought together.

Proper cleating is highly important on large flat seam roofs. Here the seams usually are soldered to make the work watertight, and expansion and contraction movements are allowed for in the cleats, which also should restrict these movements to the individual sheets.

NAILS FOR COPPER WORK

1. Use only copper or copper alloy nails; never use iron or steel.
2. Flat-head wire nails not less than No. 12 gage and not less than ⅞-in. long are recommended for wood and nailing concrete.

Some flashings, such as those around windows, doors, and gravel stops, must be nailed. In these cases the four rules for fastening still are observed. The flashing strip is fastened only along one line, and is free to move to and from the line of nailing. The longitudinal movement is cared for by placing the nails a short distance apart and by the use of soft (*R. T.*) copper. The movement during a temperature change of 120° with a nail spacing as great as 12 inches would be only 13/1000, less than 1/64-in.; entirely satisfactory with the soft copper sheet.

The danger of using iron or steel nails with copper cannot be over-emphasized. No economy results from saving a few dollars in nails which corrode and thereby ruin the roof.

a. Large Flat-Head Copper Wire Nail. (Slating and Shingle Nail)
b. Copper Wire Nail. (Similar to Steel Wire Nails)
c. Regular Cut Copper Nails.
d. Large Flat-Head Cut Copper Roofing Nail

Fig. 28

The proper nails to use with sheet copper are large flat-head wire nails, as illustrated in Fig. 28a. These differ from ordinary wire nails in design of head and of the shank immediately under the head. As can be seen from a comparison of Figs. 28a and 28b, the ordinary wire nail has a ridge or shoulder under a smaller head. This makes it impossible to drive the nail home without injuring the sheet.

Figures 28c and 28d show cut nails regularly used for shingle and tile roofing. These nails have a greater holding power than wire nails of the same length, but their disadvantages for use in sheet copper work are obvious. The shank tears the sheet and the head, if driven home, punches through, so that the sheet is badly cracked about the nail-hole. For ordinary use in wood sheathing, the holding power of the large flat-head wire nail is satisfactory.

In exposed locations, or wherever a special holding power is required, heavy (10 gage) wire nails, with barbs the full length of the shank, are recommended.

The following is a partial list of sizes and approximate count per pound of copper wire shingle and slating nails:

Length (in.)	Stubs' Gage	Approx. Number to the Pound
⅞	12	300
1	12	270
1	11	200
1¼	12	230
1¼	11	196
1½	12	210
1½	11	160
1¾	12	225
2	12	150

Cut nails of brass and other copper alloys are well adapted and recommended for slate and tile roofs. Large nails of considerable holding power are required. The length of the nail necessary to give sufficient penetration into the nailing base, which often is gypsum or nailing concrete, demands a composition harder than pure copper.

Copper and copper alloy tacks are recommended for fastening canvas decks, etc., or wherever a tack is needed that cannot rust.

SURFACES FOR LAYING COPPER

Before applying copper to any surface it should be smooth and even, and free from all small projections and hollows. Surfaces should be absolutely dry when copper is laid. In re-roofing work, over wood sheathing, the wood must be in good condition, or must be replaced before the copper is laid.

WOOD SHEATHING

Proper wood sheathing forms an excellent laying surface for sheet copper. It should be of well-seasoned, straight, unwarped boards, free from splits and knot holes. It should be firmly nailed down, all joints true and even and all nail heads set. Sheathing, after being laid, should weather a number of days, protected against rain; and no copper should be laid unless the boards are thoroughly dry.

Sheathing boards should be ship-lap, tongued-and-grooved, or splined. Ship-lap, perhaps, is the most satisfactory as it is easier to lay and offers less trouble from warping and swelling.

The ideal sheathing is kiln-dried; but such lumber is expensive and scarce, and satisfactory results can be had with air-dried boards. Green lumber never should be used for sheathing.

CONCRETE AS A BASE

When copper is laid on concrete the surface should be made smooth by a wash of neat cement. Heavy coats of asphalt paint also are satisfactory for this purpose.

Cinder concrete should not be used in contact with copper because the cinders may have ingredients which combine with moisture of condensation to form injurious solutions. Where copper is to be used over this material the concrete should be covered with a heavy coating of asphalt paint.

Some provision must be made for receiving the nails to fasten cleats. Wood battens or expansion inserts can be set into the concrete. Various nailing concretes are available. If the material to receive the nails does not extend over the entire area, it must be placed where the seams and hence the cleats will fall.

GYPSUM AND MISCELLANEOUS LAYING SURFACES

Gypsum also is well adapted for use as a base for copper roofing. What has been said of concrete also will apply to this material, except that gypsum can be nailed into directly. It is important, however, that the proper nails be specified to give necessary holding power. A 2-inch nail penetration into gypsum is required; and this, in turn, demanding nails of greater stiffness than pure copper, calls for copper alloy nails, which are available in proper design.

Other laying surfaces, such as terra cotta, stone, brick, or stucco often are encountered in flashing work. Such surfaces should be treated with neat cement or asphalt as is concrete, to insure against injuring the copper from sharp corners or projections.

BUILDING PAPER OR FELT

Under all copper roofing, valleys and gutter linings, a waterproof building paper or roofing felt should be used. It provides a smooth surface to contact the copper, and when properly lapped protects it against moisture from condensation. Over rough surfaces, such as concrete, it further is required for protection against abrasion. Over composition surfaces, where there may be slight irregularities or danger of chemical action, roofing felt is recommended particularly.

To serve these purposes the paper must be tough and durable. Asphalt roofing felt is admirable and for fireproof construction the National Board of Fire Underwriters recommends asbestos-felt paper about 1/16th of an inch thick, weighing about 14 lbs. per 100 sq. ft. or 70 lbs. per standard roll of 500 sq. ft.

When copper is used as a flashing at a junction with other roofing materials such as slates, shingles, tiles, etc., the felt or building paper under the roof covering must be lapped properly with respect to the copper. When the drainage is from the roofing onto the copper, the felt, or paper under the shingles should lap over the copper flashing or gutter lining and its underlying paper.

TREATMENT OF COPPER WORK

MAINTAINING COPPER WORK

Copper work requires little or no maintenance if properly installed. Being rust-proof, no painting is necessary, and its attractive green patina, which forms in time, is a protection as well as a beautifier. Periodic inspection should be made as a matter of routine to see that no physical damage has been done, to be sure all outlets are unclogged, and to remove all foreign matter that may have been deposited on the roof.

CLEANING OF COPPER

All copper work when finished should be cleaned of flux, scraps and dirt. On large roofing jobs this should be done as soon as the various sections are finished. Foreign matter besides being unsightly may cause permanent discoloration and other serious damage. Excess flux, which may cause acid stains, may be neutralized by washing with a 5% to 10% solution of washing soda.

For painting and artificial coloring of copper, a clean surface is essential. A slightly tarnished surface is favorable to best results. If the copper were weathered by two or three rainstorms, the surface would be in the best condition for painting or artificial treatment.

COLORING OF COPPER

Copper may be given an artificial green patina. The best process available at the present time is that described in Booklet No. 15-B "Coloring Copper, Brass and Bronze", as issued by the Copper & Brass Research Association. The process described has been used successfully, but it is dependent to a considerable extent upon weather conditions at the time of application of the treatment. There is no known process which can be guaranteed to give an exact duplication of the patina which forms in time by natural weathering.

PAINTING OF COPPER

When desired, copper may be given a satisfactory and adherent coating of paint to obtain any desired color effect. Copper to be painted must be free from dirt and oil or grease, and absolutely dry. Copper that has weathered through two or three rainstorms will ordinarily have had the oil film, remaining from rolling operations, washed from the surface. This is best indicated by the appearance on the copper of a slight tarnish resulting from its oxidation by the atmosphere. This is the best condition of a copper surface to obtain a satisfactory spread and adherence of paint. In fact, the more the copper is weathered, the better its condition for painting.

LEAD-COATED COPPER

Lead-coated copper is what its name implies—copper coated with lead.

Primarily it is a rust-proof, economical building material which increases the architect's range of expression. It affords a wide variety of tones and finishes, from the metallic gray of newly cast lead to the soft weathered antiques, and from the neatest of smooth surfaces to those that are extremely rough.

By its use the architect is enabled to harmonize colors in a wide field and yet meet the practical problems of building. He can obtain the effect of lead with freedom from various difficulties encountered where that material is used alone, especially the necessity for heavy construction. For roofs and for flashings, gutters and downspouts the material offers the economies of sheet metal application with freedom from any rusting of the base metal.

In common with plain copper, lead-coated copper has among other advantages:

1. Distinctive beauty
2. Reasonably low cost
3. Strong, stiff sheets
4. Lightness in weight
5. Ease of application
6. Rustproof qualities

It can be used for most metal work on a building—roofs, domes, spires, spandrels, marquees, a wide variety of ornamental work. It is a possible finish for window frames, doors and for similar structural units; also for flashing, gutters and downspouts and for ornamental leader heads.

The soft tones of lead-coated copper harmonize with many popular building materials, a great variety of stone and numerous shades of brick. And with it goes the assurance that the underlying metal is rustproof.

In a sense, lead-coated copper is a new development in the field of useful metals; and yet it has been in service sufficiently long to have proven its value in a practical way as well as for ornament. So far as it is of record, the first application in the building field was just prior to the World War. It was the inspiration that came from a desire to develop a material which would give the appearance of cast lead at a much lower cost and with less dead weight.

From that time forward the use of lead-coated copper grew in popularity. Some splendid examples of various applications, all sponsored by eminent architects, are in existence.

HOW TO SPECIFY SHEETS

First, the architect should decide on the weight and temper of the copper to be lead-coated. For ordinary roofing and other sheet metal work 16-oz. copper is the accepted minimum but where special circumstances are involved, increased weight may be desirable. Soft (roofing temper) or hard (cornice temper) copper can be lead-coated, but it should be remembered that heat from the molten lead as applied, removes some of the temper and it is often desirable, as for example in cornice work, to increase the gage of the copper sheets to assure required rigidity. Where the sheets are backed or supported, as in roofing, flashings, etc., soft temper is proper for the base copper.

Lead-coated copper is furnished in accordance with the American Society for Testing Materials specification B-101. This specification covers lead-coated copper for different weights of copper sheet and different weights of coating. The weight of coating is designated as the total weight of lead applied to two sides of 100 sq. ft. of copper sheet. Sheets may also be coated on one side only, or with special texture and finish, under written agreement between the purchaser and the manufacturer.

Thus, for general roofing work the architect would write his specification for lead-coated copper to read, for example, as follows: "The lead-coated copper sheets shall be furnished in accordance with A.S.T.M. Specification B-101 and shall have the Class B coating (20 to 30 lbs.) applied to 16-oz. soft (roofing temper) copper sheets."

METHOD OF APPLICATION

The method of applying lead-coated copper for roofing and other sheet metal work is precisely the same as for plain sheet copper. The same types of seams and solder are used as for plain copper.

LEAD-COATED SPANDRELS, ETC.

The subject of lead-coated copper or copper alloy spandrels, vertical trim, horizontal band courses, and mullions requires special consideration. Made of formed or stamped sheets, they vary in size and in method of construction, as well as in the gage of metal. There also is a wide latitude in practice as to method of framing and connecting unit parts, as well as in anchoring or securing them in place.

Because of the variety of design of spandrels, etc., specifications will depend on the conditions of each installation. If special problems arise in connection with this subject, information may be obtained from this Association.

As for the lead-coating of copper for vertical surfaces, the same general rules apply as for the lead-coating of copper sheets.

TINNED COPPER

Copper sheets tinned over their entire surface should never be used for any type of roofing, flashing or gutter work. They are subject to pitting and would fail in such service in a relatively short time.

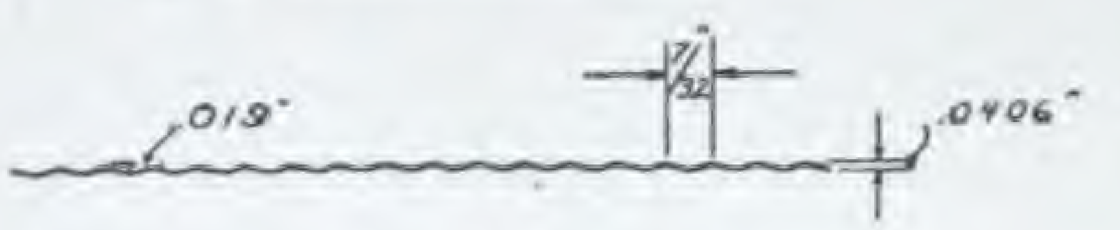
CRIMPED COPPER

The use of crimped copper is well established, and is admirable for formed elements such as cornices, domes, cupolas, ornamental figures and urns, etc., to care for expansion and contraction. The small crimps permit a kind of bellows action not possible in plain sheets. It is well suited for vertical walls and plain and panelled areas. As shown in Fig. 28-A below, the crimps consist of 7/32 inch V-shaped corrugations running crosswise with the length of the sheet. Crimping tends to harden the copper, although not greatly.

The widest use of crimped copper probably is for cornice work, both for ornamental and practical reasons. It gives a nice finish to the plane surfaces of cornices and the crimps allow opportunity for expansion and contraction.

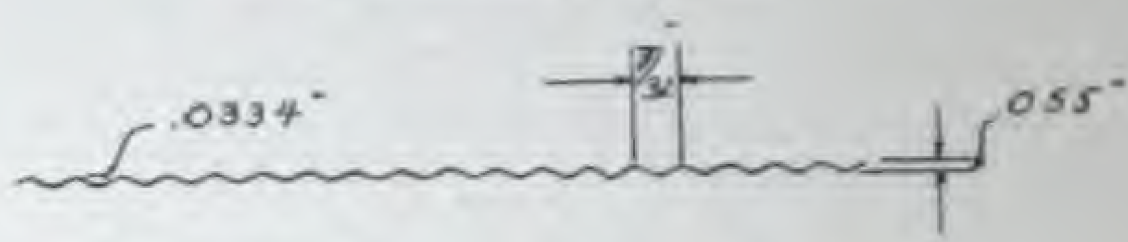
Crimped copper can be used for through-wall flashings but the crimps should not be expected to furnish a complete masonry bond. The corrugations of crimped copper are not deep enough for this purpose. The type of construction shown in Figures 81 and 82 or the various patented flashings referred to in the section on Flashings (page 62) should be used.

16 Oz. Standard Crimp



REDUCTION IN LENGTH OF SHEET
30" x 96" Sheet 36" x 96" Sheet
3/4" in 96" 1" in 96"

16 Oz. Heavy Crimp



REDUCTION IN LENGTH OF SHEET
30" x 96" Sheet & 36" x 96" Sheet
5" in 96"

Fig. 28-A

CORRUGATED COPPER

Corrugated metal is that in which flat sheets have been rolled into parallel symmetrical waves. The corrugations can vary in width and depth but usually are in the form of circular arcs. Typical corrugations are shown in Fig. 49.

The purpose of corrugations is chiefly to give added strength to the sheets, and they aid in the discharge of rain water. Corrugated copper sheets most frequently are used in heavy gages. The wings of the United States Capitol were roofed in 1859 with corrugated copper which still is giving perfect service without a single expenditure for repair or maintenance. The metal in this installation is at least 30-oz. copper, and sheets 24 ins. wide were laid on purlins spaced 24 ins. center to center. They are fastened to the purlins by angle brackets riveted to the sheets and fastened to the upper side of the purlins by bolts. As there is no sheathing or other support under the whole sheet, the necessity for using heavy metal is obvious.

Tests run on corrugated copper sheets under uniform distributed loads showed, as would be expected, that sheets laid continuously over two spans give decreased deflection and a more rigid roof. The amount of permanent set in the sheets tested under load was found to be very small after six weeks and the rate of increase of the set after this period was inappreciable.

The method of laying corrugated sheets is covered further under the discussion of roofing on page 38.

LIGHTNING PROTECTION

Complete rules and directions for installing lightning protection systems are published by the Underwriters' Laboratories, 207 East Ohio St., Chicago, Illinois. This Laboratory was established and is maintained by the National Board of Fire Underwriters. They also list a number of companies whose lightning protection systems conform to standards they have established for their "Master Labeled Lightning Protection Systems."

Copper roofing of all kinds and its accessories, such as downspouts, may act as excellent adjuncts to lightning protection systems, but are not recognized by Underwriters' Laboratories as a substitute therefor. All such copper work coming within six (6) feet of lightning conductors should be interconnected with them by a conductor of not less than an equivalent of No. 6 B. & S. gage copper wire. Extensive copper roof areas that do not come within this distance of a regular lightning protection system should be independently grounded.

SECTION II—ROOFING

In designing the construction upon which the roof covering is to be placed; the limitations and demands of the roofing material to be used, drainage arrangements, and the type and design of the gutters must be considered. Information on drainage begins on page 97.

Roofs may be flat, pitched, or made up of a combination of slopes. While this leads to a large variety of styles, the principal types, of which all others are variants, can be confined to:

1. The gable
2. The hip
3. The gambrel
4. The mansard
5. The flat

The first four are shown in Fig. 29, and the flat type needs no explanation.

Copper can be used on all types of roofs. It is, furthermore, the universal flashing and accessory metal used with all the better class roofing materials. The five standard methods of applying copper for roofing are as follows:

a. Batten or ribbed seam
b. Standing seam
c. Flat seam
d. Corrugated copper roofing
e. Copper shingles and tiles

The first three methods make use of flat sheets, and these, together with corrugated roofing, will be discussed in detail. Copper shingles and tiles, due to the variety on the market, will only be touched on; detailed information can be obtained from individual manufacturers.

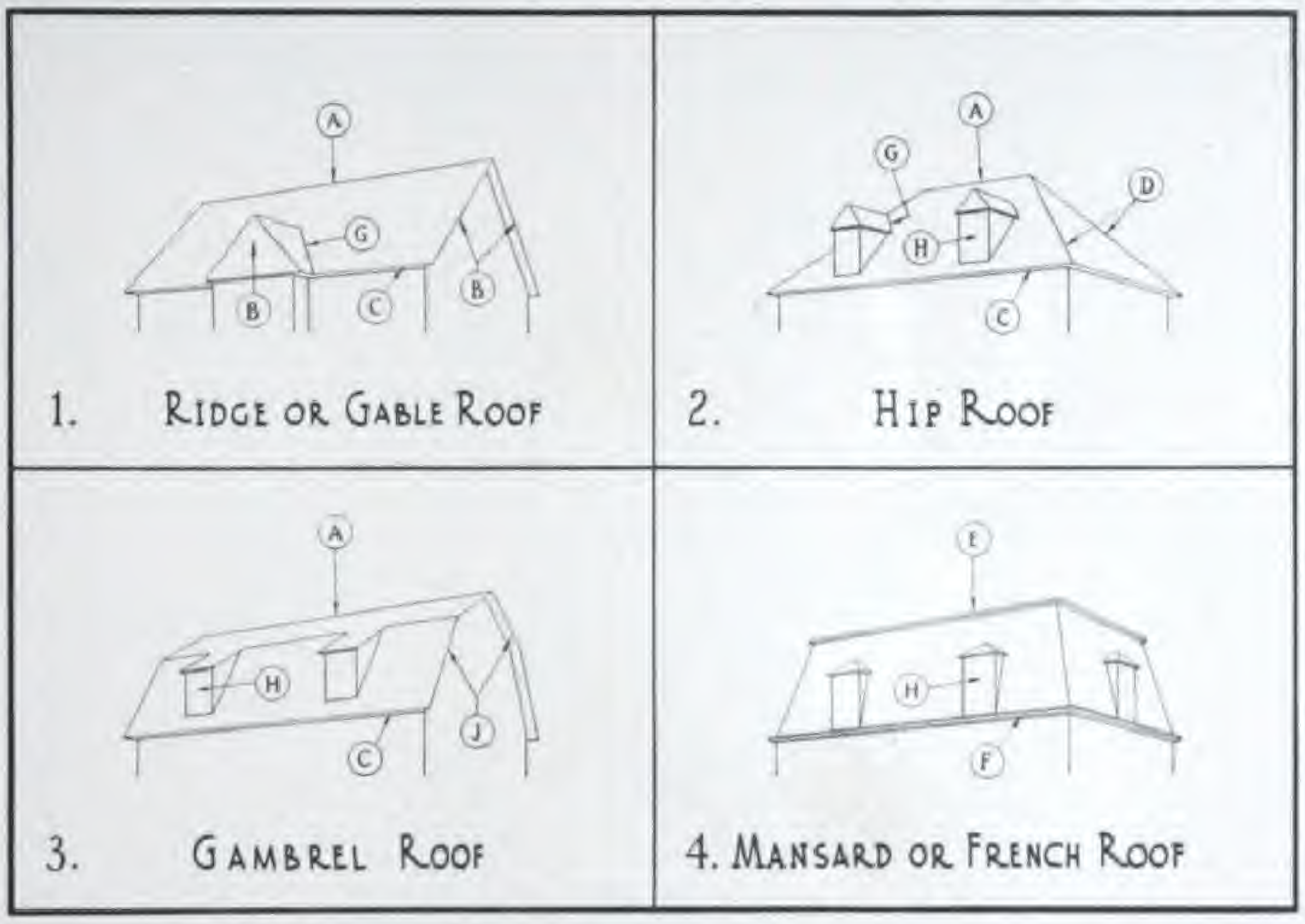


FIG. 29 A. Ridge B. Gable C. Eaves D. Hip E. Deck F. Cornice G. Valley H. Dormer J. Gambrel

SOLDER AND WHITE LEAD

It is highly desirable in copper work to eliminate soldering wherever possible so the sheets are free to move. Copper roofing held with loose-lock seams and cleats is free to move, but treatment of the seams to make them watertight is necessary if water can back up over them or be drawn into them by capillary attraction. On steep slopes of 12 inches to the foot or more, which drain rapidly, seams do not need to be treated. Here and on domes and towers the seams often are filled with white lead paste, (see page 15), to give insurance against leaks from driving rains and snow.

In batten and standing seam roofing, lateral expansion and contraction are amply provided for if the copper is laid with consideration to present and future temperatures. Longitudinal movement is more difficult to handle if the cross-seams cannot be left unsoldered. In such cases the use of 4 ft. sheets, instead of the standard 8 ft. sheets is recommended. Employing smaller sheets introduces more seams which tend to stiffen the surface and prevent buckling.

For low pitches, special attention is directed to the "strip-pan" method of forming the cross-seams in batten and standing seam roofing. This does away with soldering and makes the joints watertight by providing the required head lap.

In flat seam roofing solder must be used wherever water could back up from outlet stoppage or wherever snow or ice can collect. The method of providing for expansion and contraction in this type of construction will be discussed under flat seam roofing. (See page 34).

SLOPES

The slope or slopes of a roof, having been determined by the style or architectural design of the building, and climatic and drainage considerations, will determine in large measure the application of the copper, both as to the standard method to be employed and details of its use. In general, the flat seam method is used for flat roofs and decks, and for domes and cupolas; the standing and batten seam methods, and copper shingles and corrugated sheets, for sloping roofs. The limitations of slope in the five standard types of copper roofing are as follows:

a. Batten seam—can be used on slopes of 3″ per foot and greater.

b. Standing seam—can be used on slopes of 2½″ per foot and greater.

c. Flat seam—can be used on slopes of ¼″ per foot and greater.

d. Shingles or tile—(See manufacturers' specications.)

e. Corrugated—can be used on slopes of 4″ per foot and greater.

Three methods are in general use for defining the pitch or slope of a roof:

1. In terms of vertical rise in inches, to each foot of horizontal run, as—"one inch to the foot".
2. In terms of a fraction denoting the ratio of the total rise of the roof to its total span, as—"¼ pitch or slope". (That is, the height of the roof is equal to ¼ of its total span, assuming two equal and opposite intersecting slopes. For a single slope the fraction is obtained by dividing the vertical projection by twice the horizontal projection).
3. In terms of the angle, measured in degrees and minutes, between the roof slope and the horizontal, as—"slope of 18° 25′ ".

Figure 30 presents an easy means of conversion from one nomenclature to another.

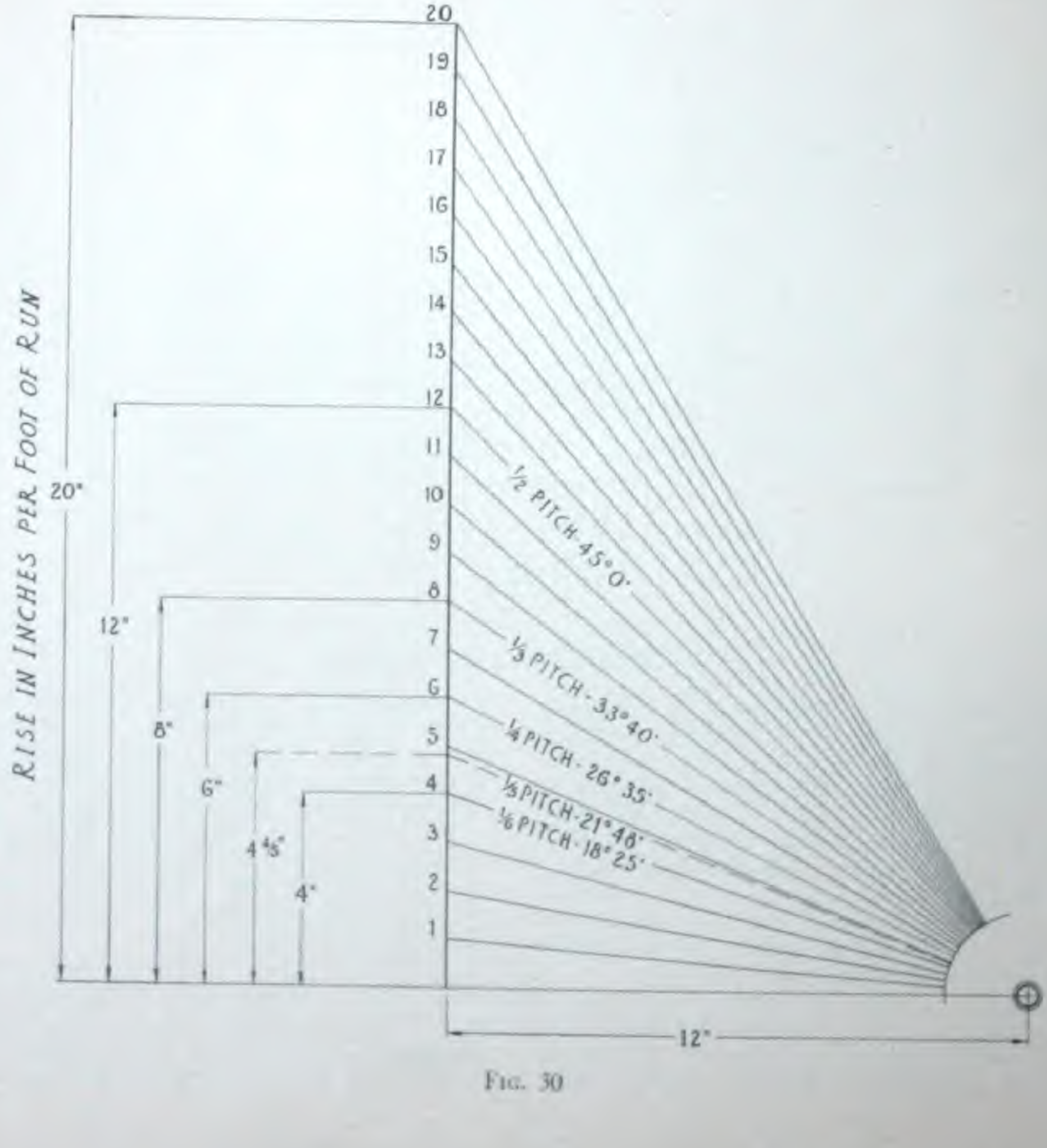


Fig. 30

BATTEN OR RIBBED SEAM ROOFING

In this type of roofing the surface is broken up by evenly spaced battens or ribs laid parallel and running with the slope of the roof. The roof covering is made of soft (roofing temper) copper sheets formed between battens, and caps over the battens locking into the sheets. This construction safely provides for lateral expansion and contraction, if due consideration is given at time of laying to local temperature ranges.

The artistic effect of these ribs makes the batten seam excellent for large roof areas of public buildings, churches, cathedrals and large residences as it provides dignity and ornamentation. This type can be used on slopes of 3" to the foot or more. It always should be borne in mind that the longitudinal seams at the battens are unsoldered and, therefore, not watertight. It is not always safe accordingly to use the batten method on slopes as low as 3" to the foot in localities where quantities of ice and snow may collect and at melting cause water to back up over the battens. Such special local conditions must be considered when roofs are designed.

TYPES OF BATTENS AND KINDS OF MATERIAL

Battens usually are wooden strips securely fastened to the laying surface. A variety of shapes are possible, as shown in Fig. 20, but for general use the types illustrated in Fig. 31 are recommended. They are usually cut from a square or rectangular strip with the sides bevelled so that they are symmetrical. The bottom corners are bevelled off slightly (A or B), or undercut (C), to allow freedom of movement to the copper sheet.

Such battens preferably are made of cypress, although spruce and pine commonly are used. They should be dry, straight and sound. The surface should be smooth and all nail heads should be set. If bolts or screws are used, their heads should be countersunk.

Battens of heavy copper or copper alloy can be used. Their design should follow the principles recommended for wooden battens and their installation, including all fastenings, should be in accordance with the general rules for copper work. These battens are admirable for important construction and are recommended in such cases.

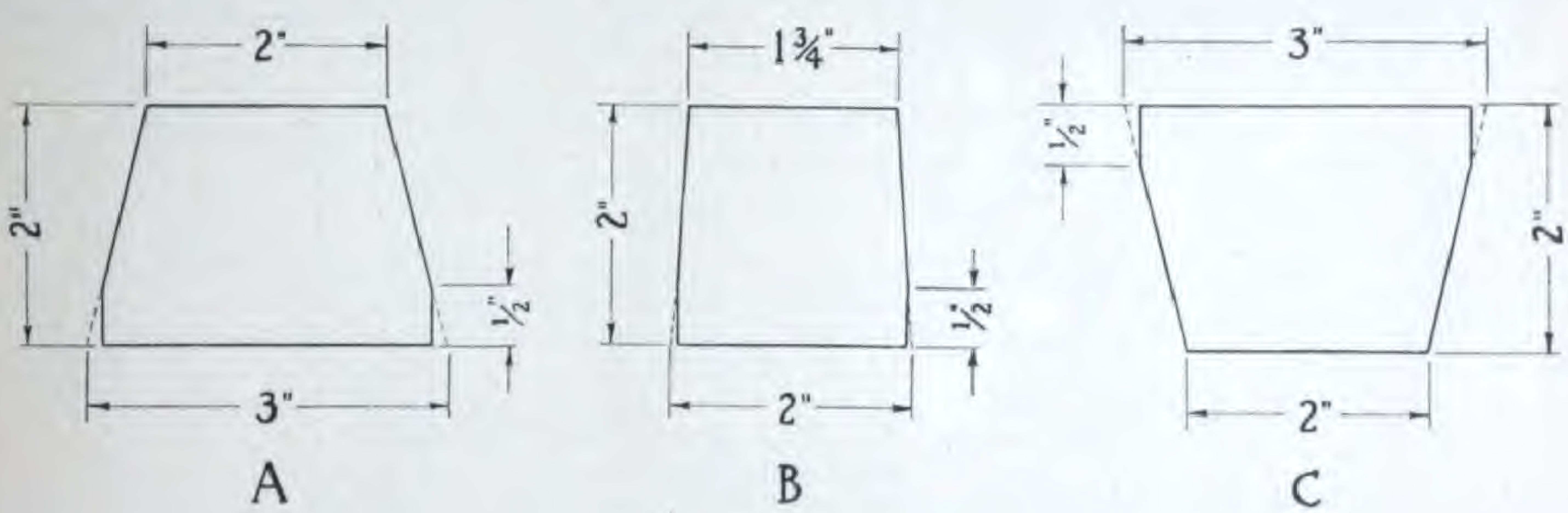


Fig. 31

SIZE AND SPACING OF BATTENS

The size and approximate spacing of battens usually is determined by architectural considerations. They are ordinarily spaced from twenty to thirty inches apart, the exact spacing being adjusted to fit stock widths of copper sheets. From the mechanical standpoint, spacing near the lower of these limits is recommended.

SIZE OF COPPER SHEETS

Copper sheets are stocked in widths which are multiples of 2". If battens of type B, above, are used, the width of the sheets should be three inches greater than the distance from center to center of battens.

> Example: If the rib is 2" x 2" and the spacing of ribs 21" center to center, the width of the sheet necessary is 21" less 2" (width of one rib) plus 4" (turn-up of sheet against two ribs) plus ½" plus ½" (allowance for two locks) which equals 24".

The standard length of sheets is 96 inches, and they are available with or without the crosswise edges tinned. It sometimes is advisable, where the cross seams must be soldered on long runs, to cut the sheets in half and use 4-ft. lengths, thereby introducing additional seams which act as stiffeners against buckling. Cross seams in adjacent bays should be staggered, and alternate bays often are started with half length sheets.

Design using sheets 24 inches wide is recommended. Cross seams should be unsoldered whenever slope and other conditions permit.

Fig. 32 shows a typical bay laid with the batten seam method. Figure **32A** illustrates the steps in forming the batten seam. (1) Cleats 2″ wide and 3″ long are nailed to the sides of the battens. They should be of 16-oz. copper spaced from 8″ to 12″ apart, secured by two copper nails with ends of cleats turned over to cover nail heads. (2) Copper sheets of required width and properly formed are placed on roof between battens and against and under cleats. The long edges of the sheets have been turned up at right angles, and the final ½″ turned at right angles again. (3) The sheets are secured by turning the free ends of the cleats down and back to engage the edges of the sheets. (4) The rib is covered with a copper cap of proper width, the edges folding back on themselves to engage the edges of the sheets. (5) With the caps in place, the edges are dressed down against the batten, forming ½″ lock seams.

The sheet may be treated in a number of ways at the cross seams and at the corners. Solder should be eliminated where possible, to care for expansion and contraction. Two common methods of handling sheets are as follows:

1. *Roll Method:* Full length sheets are flat-locked and soldered together in sufficient number to extend from the ridge to the eaves. Half-inch seams are used. The strips or rolls are formed as just described, with roofing tongs on the job. This method is satisfactory only for short runs that connect directly to eaves. Allowance for the expansion and contraction required by the continuous lengths then can be made at ridge and eaves.

2. *Pan Method:* Sheets eight feet long (or shorter), are formed to required shape in a brake at the shop. Individual sheets, after bending, are known as pans. This method allows cross seams to go unsoldered, if pitch is sufficient, and is recommended for most work. On roofs with a pitch of 12″ per foot, ½″ unsoldered flat-lock seams are satisfactory. For lower slopes, ¾″ seams or the method shown in **Fig. 32B**, should be used. Do not notch the sheet when forming cross seam locks. The closing of such seams, when the sides of the pans are bent up, can be prevented by inserting a strip of leather or sheet lead into the lock. On low pitches, or where the head lap afforded by a ¾″ seam is not safe against leakage, cross seams should be soldered, or the "strip-pan" method of **Fig. 33**, should be used.

The temperature at time of laying should be kept in mind so allowance can be made for expansion, contraction, or both. If a batten seam roof is laid in cold or moderate weather, at least ¼″ should be left between the pans and the bottom of the battens for expansion in hot weather. (See page 5).

A NOTE AND SOME DON'TS ON BATTEN SEAM CONSTRUCTION

The finish of the batten at ridges, hips, valleys and eaves, or at the connection between batten roof areas and built-in gutters, and at flat seam areas such as crickets, etc., is most important. The function of batten construction is to break up the roof area into small units so that the amount of expansion and contraction at any one point is negligible. If the batten sections are soldered to other roof areas which do not provide properly for expansion and contraction, the effect of the batten construction is nullified.

DO NOT solder side batten covers with a flat lap seam (Fig. 6) to ridge or hip batten covers. See Fig. 34.

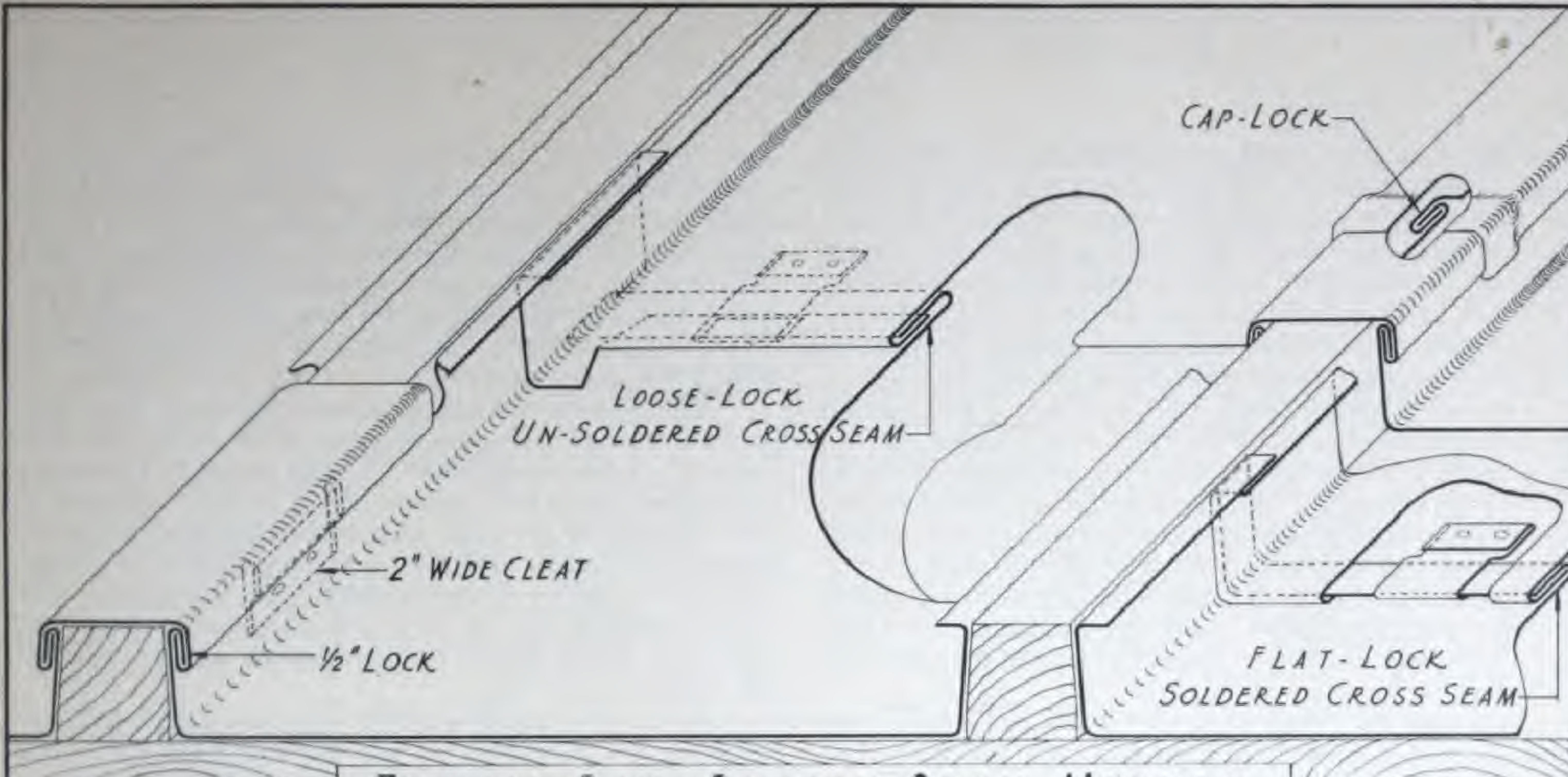
DO NOT cut off the batten a few inches before it reaches the eave or gutter edge, leaving a strip of flat soldered copper at that point, which nullifies all effect of the batten construction of the main roof area. Instead, continue the batten over the edge as in Fig. 37.

DO NOT cut off battens a few inches before their intersection with valleys, for reasons similar to the above. Extend the batten over the valley metal with the batten section loose locked to the valley, as in Fig. 36.

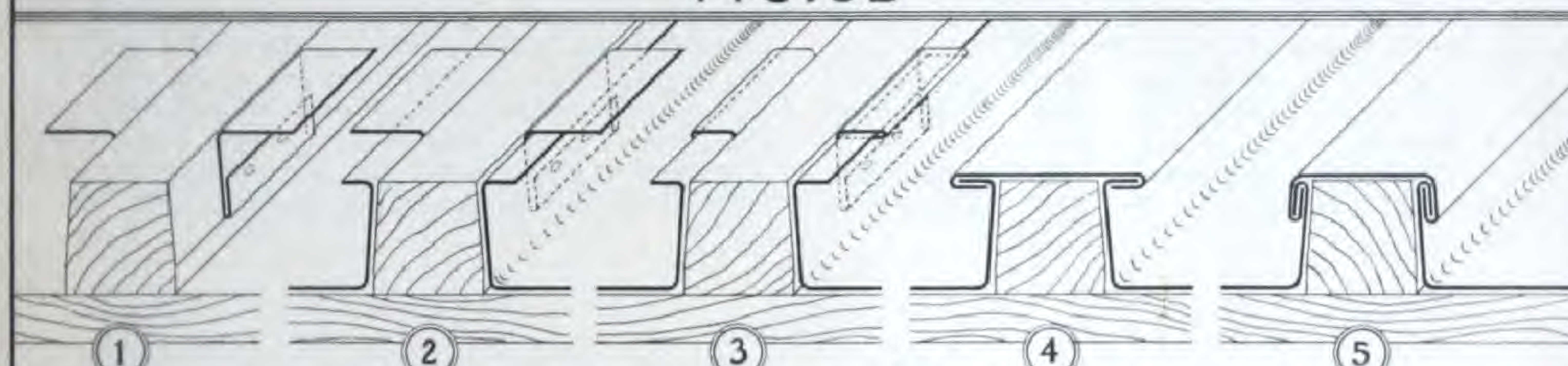
DO NOT solder batten areas to flat seam areas. Use a loose lock seam (filled with white lead if necessary) with the same type of construction as in Fig. 36.

DO NOT dress the batten pans tight up against the battens. Leave a good fillet and room for movement. See Fig. 20 and discussion thereof.

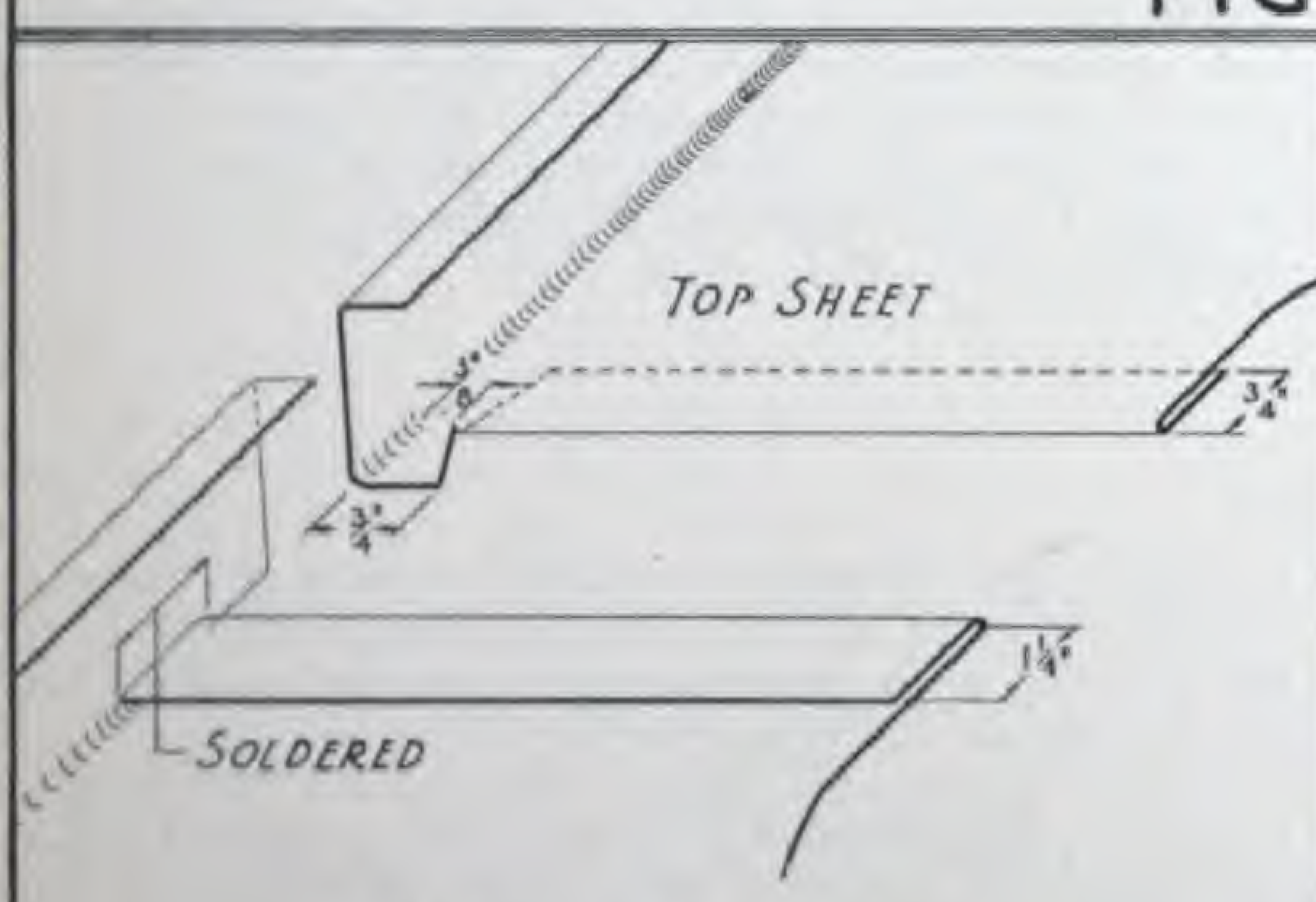
DO NOT use narrow single-nail cleats, and DO NOT use ferrous nails. Use wide cleats, secured with two non-ferrous nails as shown in Fig. 32 and elsewhere.



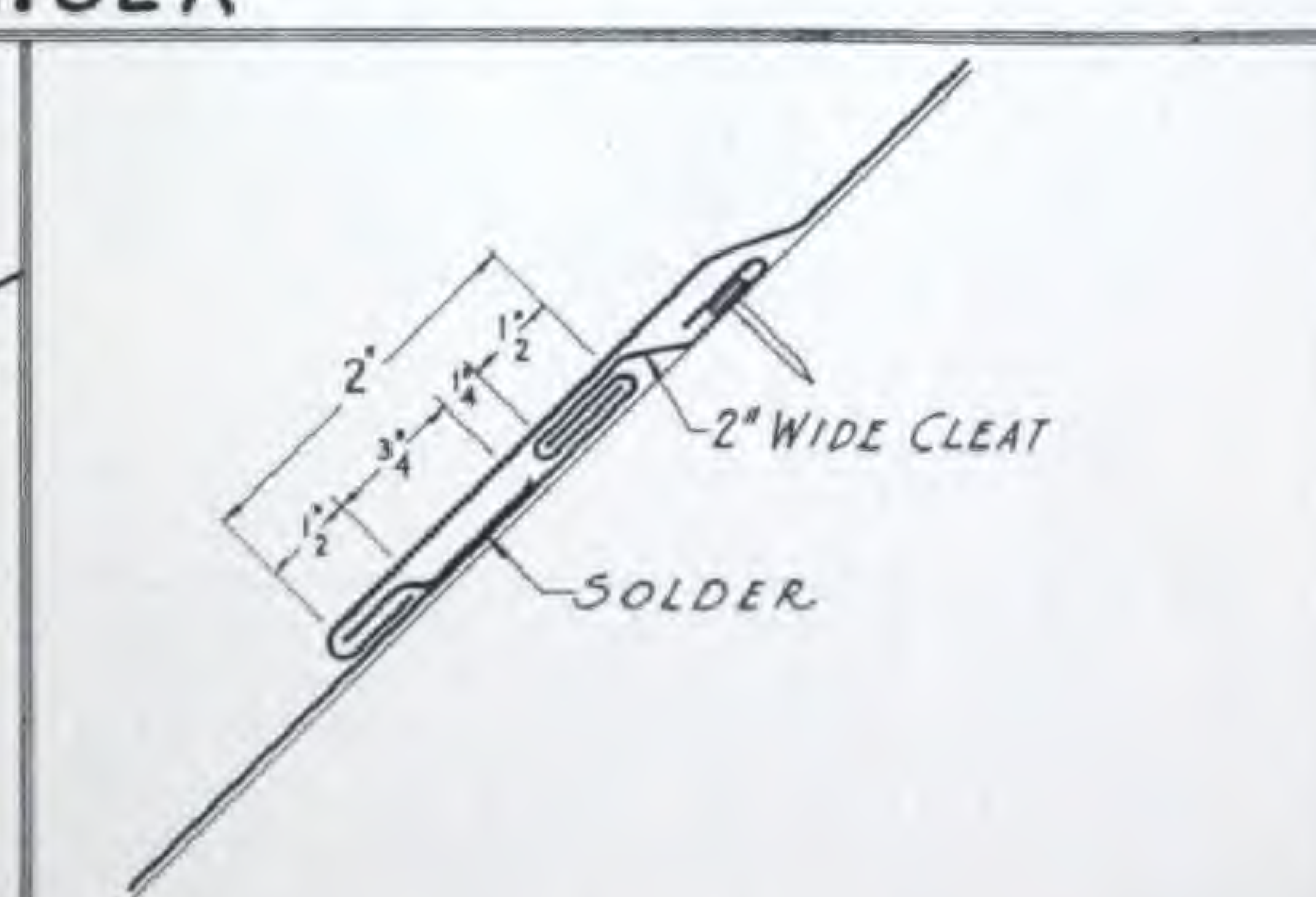
TYPICAL BAY-BATTEN SEAM METHOD
FIG. 32



DEVELOPMENT OF A BATTEN SEAM
FIG. 32A



SHEETS FORMED FOR
LOOSE-LOCK CROSS SEAM
FIG. 32B



STRIP-PAN METHOD
FIG. 33

BATTEN ROOFING DETAILS

Ridges or Hips

Fig. 34 shows method of constructing a batten seam ridge or hip. Here the dimensions of the ridge batten are controlled by the slope of the roof so the roof battens meet it with tops flush. The roofing sheets are cut so they can be turned up in the corners against both battens and have ½" flanges left to receive cap sheets. An accurate pattern should be made (similar to that in Fig. 38B) to insure proper fitting of the sheets.

The tab marked "lap", which is part of the side of the pan, is folded back of the sheet and soldered watertight before the sheet is laid. An alternate method, which is preferred by many good roofers, is shown in the small circle. Instead of cutting a tab out at the corner, the excess metal is folded back of the turn-up of the pan, against the ridge batten. This method eliminates the use of solder, which is always desirable. After the pans have been cleated in place, the batten caps are slid on and locked.

As shown in Detail A, a tab on the top end of the batten cover is turned back, to lock into the ridge cap. The ridge cap is then fitted into place so as to lock into the top of the roof pan, and the top tab of the batten cap. Between battens this turns down against the ridge batten. At the side battens the flat lock lies on top of the batten cover as shown.

There remains the problems of providing for longitudinal movement of the side and ridge or hip batten covers. These should be formed from strips not over 8 ft. long, locked into adjacent sections. Care should be taken to avoid bringing a joint in ridge or hip cap at the point of intersection of the side battens. Where possible with drainage conditions, it is advisable to leave these locks between adjacent caps unsoldered. In any event they should not be soldered into lengths exceeding 30 ft. If the ridge or hip dimension exceeds this, then some form of loose lock or slip joint should be provided to permit movement. The locks can be filled with white lead paste if necessary.

Other details of construction can be used. The ridge batten instead of being finished flush with the side battens, can be made higher. In this instance a separate extension of the side batten cap is usually soldered to the top end of the cap. This locks into the turned-up ends of the pans, and at the top locks into the ridge batten cap. While this method has some advantage over that shown in Fig. 34, it is not so simple as that construction and is difficult to accomplish without the use of solder.

Still another method which is occasionally used is to dispense with the ridge batten entirely. In this case the tops of the pans are locked over the ridge in a manner similar to that of the standing seam construction shown in Fig. 39. Batten caps from opposite sides are also locked at the peak or else covered with a separate cap. (A modification of this method can be used where there is a change of slope.) Because of the strain put on the copper in the corners of the sheets in forming the seams, this method is not suitable if the angle between the opposite roof slopes is less than 135°. Where the angle is less than that, a ridge batten should be used.

Gable Ends

Fig. 35 shows four methods of finishing batten roofing at the sides or gable ends. Details 1 and 2, making use of ribs along the gables, have the advantage of keeping the water from dripping over the edge of the roof. If a low finish is desired, a drip edge should be provided as suggested in Details 3 and 4. The methods of fastening virtually are interchangeable. Additional information on this subject will be found on page 62. Nails or screws should be placed from 8" to 12" apart.

Detail 1 is applicable where the roof finishes in a metal cornice, but with nailing as shown the cornice either must be narrow (less than 12") or built up of sheets loose-locked together to take care of expansion and contraction. In Detail 3, where the roofing is nailed, a flat-lock seam caulked with white lead is inserted unless the last batten is within about 12" of the edge. Detail 4 makes use of a brass edge strip further described in Fig. 89A.

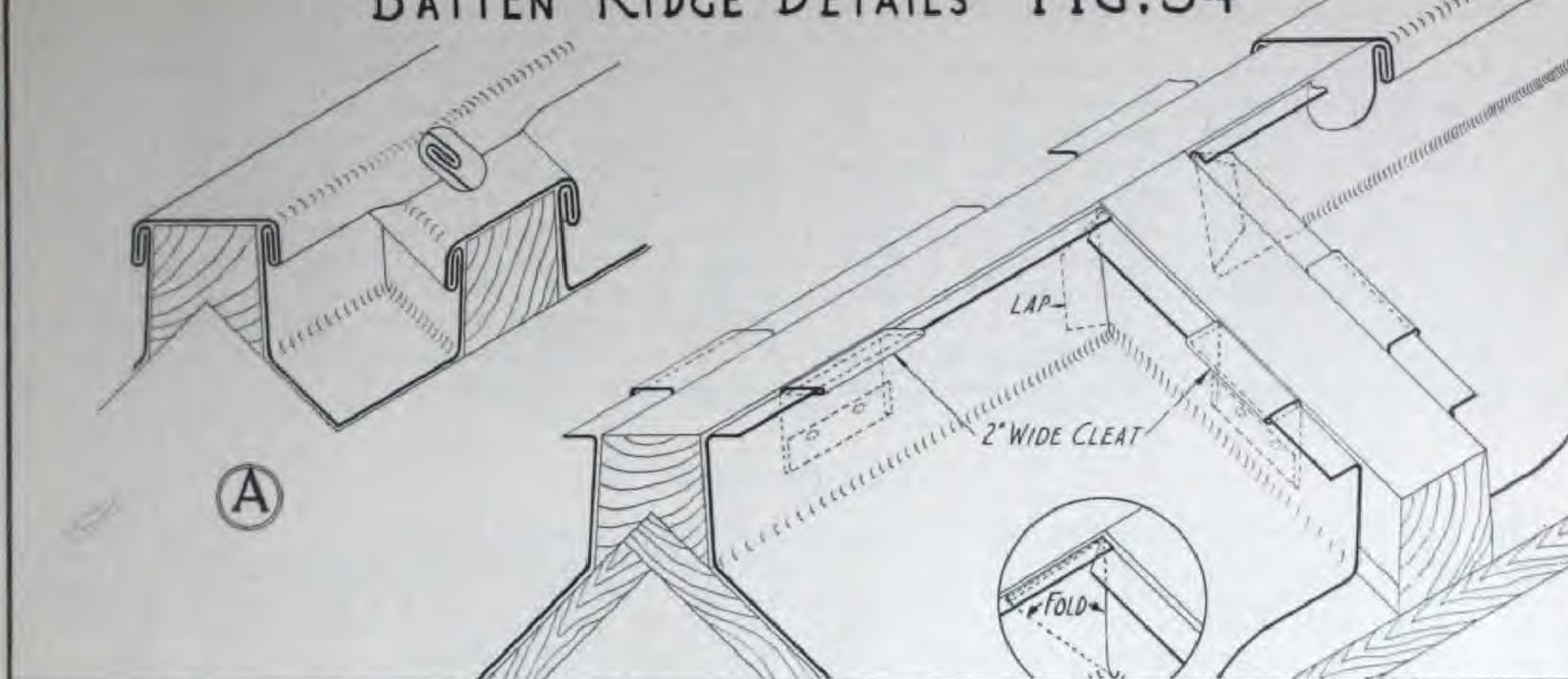
Valleys

Fig. 36 shows method of finishing batten seam roofing at a valley. The valley is constructed with continuous fold-over crimps into which the roofing sheets can be locked as shown. A final fold is provided along both edges of the valley for cleating. The sheets and caps are folded around the batten ends and secured with lock seams.

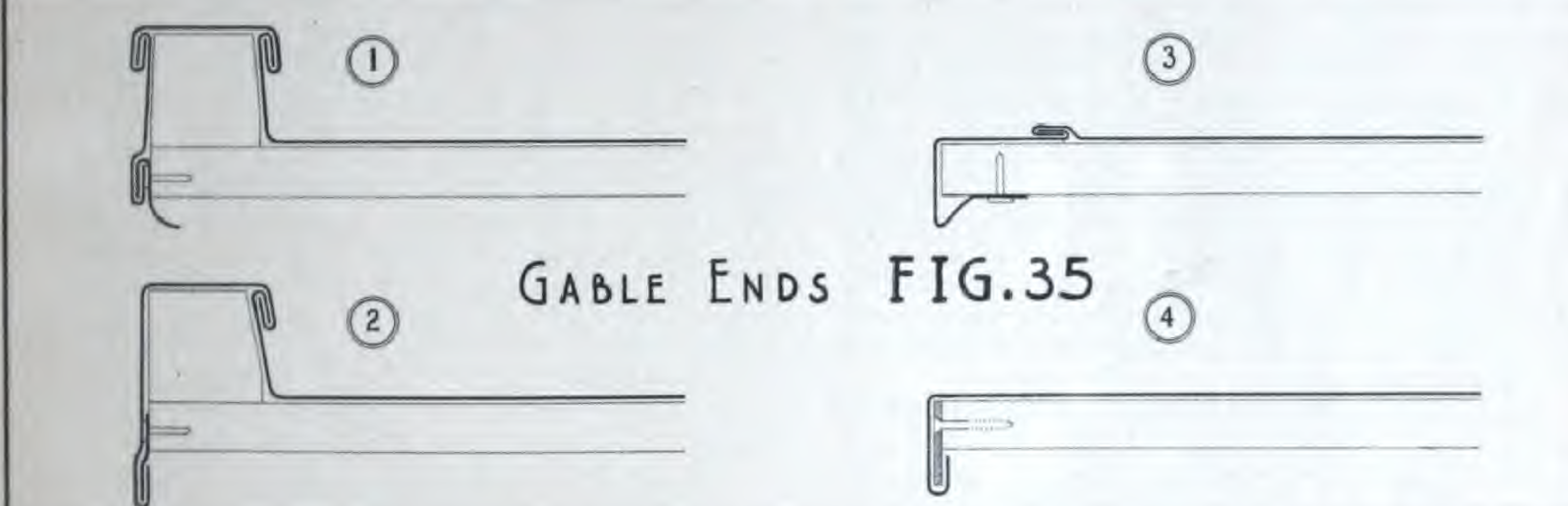
The method of laying out the sheets at the batten ends is shown in Detail A. The pans are cut at the ends so the portions up the sides of the battens have tabs projecting beyond the batten ends, and the portions on the roof have the ends turned back into the valley crimp. Auxiliary pieces to fit over the batten ends are formed and slipped inside the ends of the roofing sheets. These end pieces are cut the shape of the batten end but ½" larger all around, and the corners are cut out so that the extra ½" can be folded toward the front at the top and sides, and back into the valley crimp at the bottom, as in Detail 1B, Fig. 37.

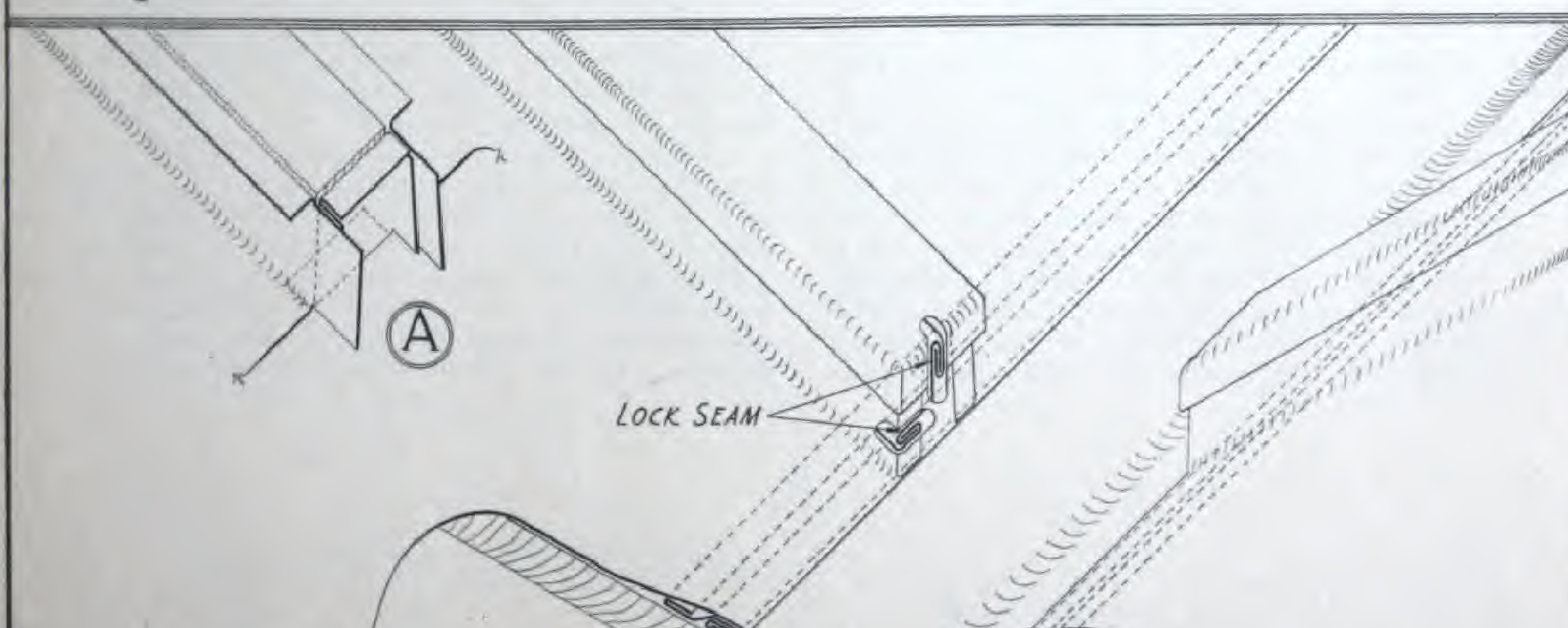
The 1" tabs on the sides of the pans are folded back ½" to engage the sides of the end cap, and these locks are folded flat against the batten end. Finally, the batten cap is placed, and locked to the pans as usual. The end of the batten cap has been cut so that for the width of the batten top it projects 1" beyond the end of the batten. This tab is folded under and back ½" to engage the top flange of the end cap, and this lock is then folded down against the batten end. The vertical seams along the corners of the batten cap finally are soldered tight.

BATTEN RIDGE DETAILS FIG. 34



GABLE ENDS FIG. 35





BATTEN SEAM AT VALLEY FIG. 36

Eaves

Fig. 37 shows two methods of finishing batten roofing at eaves and gutters.

In detail at the left the use of the end piece (Detail 1B) and the method of locking the pans and batten cap to it are identical to the valley finish shown in Fig. 36. As brought out in Detail 1A, the batten projects slightly at the eaves, and the bottom is sliced off at the end to give room for the edge fold of the gutter lining which is continuous along the roof for cleating. A crimp is put in the gutter lining under the end of the batten so the end piece may be locked over it.

In the right hand detail an alternate method uses an auxiliary sheet under the end of the batten. This sheet is about 6″ square and has a fold-back at front edge to engage a crimp in the gutter lining. An end cap the shape of the batten with ½″ tabs all around also is used, but instead of being locked to the roofing sheets and batten cap, it is merely slipped over the end after the sheets have been cleated. The top tab is folded down and nailed to top of batten before the batten cap is placed, and the bottom edge is hooked over the gutter lining. The side tabs are folded back against the sides of the pans and soldered. Finally, the batten cap is placed and locked to pans as usual. This method should not be used without auxiliary sheets, which cut off possible leaks at batten corners.

Wall Finishes

Fig. 38 shows method of finishing batten roofing against walls or parapets.

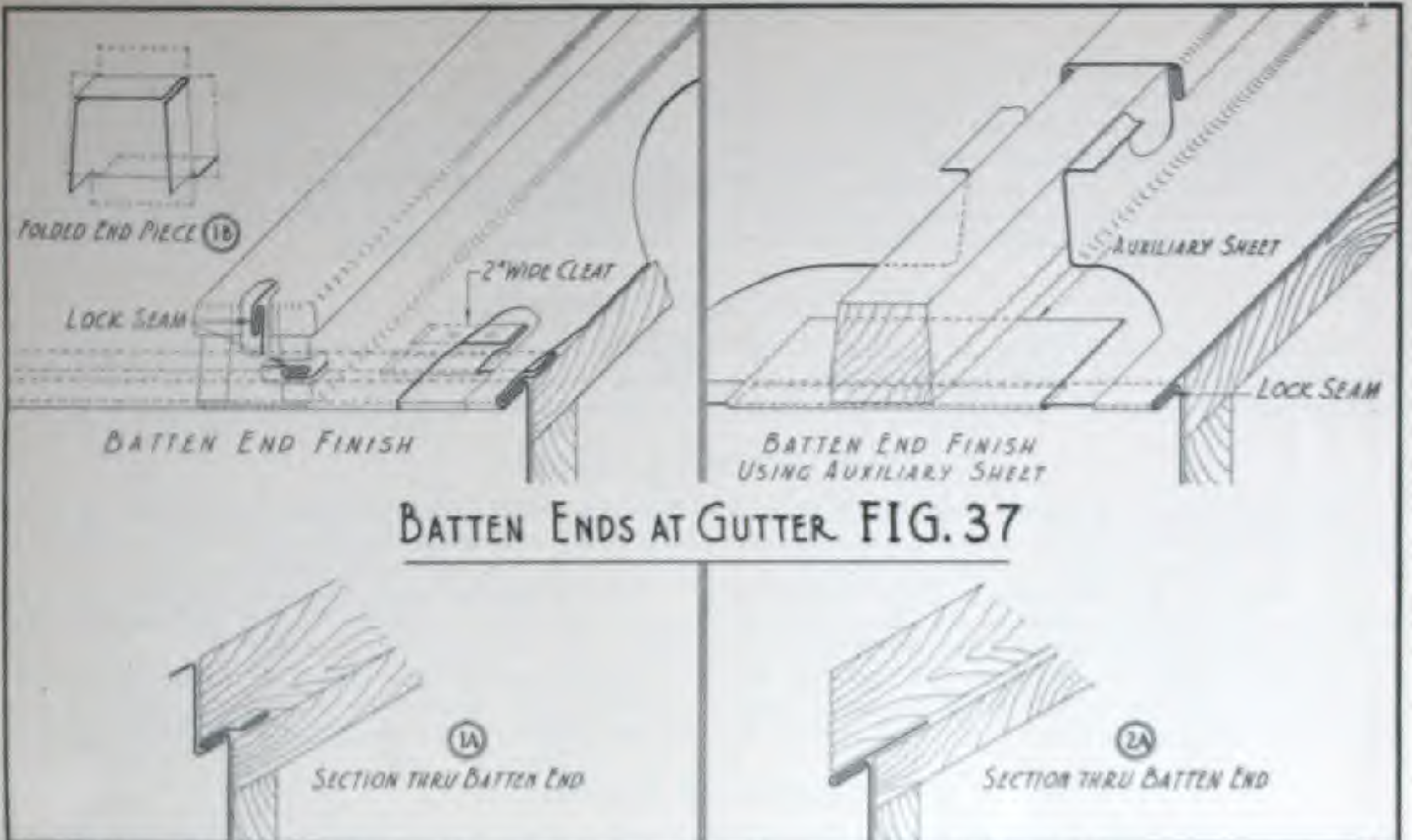
At the left is shown a side wall where the last pan is turned up against the wall at least 6″ to act as a base flashing, and is held by cleats previously nailed to the sheathing about 12″ apart. Cap flashings stepped up the wall as required by the roof slope lap the base flashing at least 4″. The cap flashings extend into the brickwork at least 2″ and should be installed as the masonry progresses. If inserted after the wall is built they are held with lead plugs 1″ wide spaced 8″ to 10″ apart, as described on page 36. Note fold for stiffness along bottom edge of the cap flashings, and the inner edge fold to give better anchorage. Cap flashings should have a side lap of at least 3″. If, by their location and size, cap flashings seem likely to curl up or be lifted by wind, heavy brass straps or brackets extending down over each flashing can be anchored into the masonry at intervals up the roof.

When a batten roof slopes from a wall, one type of construction is shown in Fig. 38A. The pan sheets are cut at corners so they can be turned up against the wall as well as against the battens in the usual way. They extend up the wall the height of the battens with ½″ of additional metal forming a lock with the wall sheathing. The construction is quite similar to that of Fig. 34 in many of its details. The tabs (shown dotted) are folded against the backs of the ends of the pans and soldered. Instead of soldered tabs it is also possible here to use the fold-back corner shown in the circle in Fig. 34. When the batten cap is placed it has an extra ½″ at the upper end, the width of the batten top, which is folded down to form a hook. Finally, the wall sheathing, which has been provided with a continuous ½″ fold along the bottom edge, is locked into the pans and batten caps, and the seam is dressed down, flat on top of the battens, and vertically against the wall, giving a wave effect at each batten. This lock should not be soldered, but can be filled with white lead if there is danger of leakage.

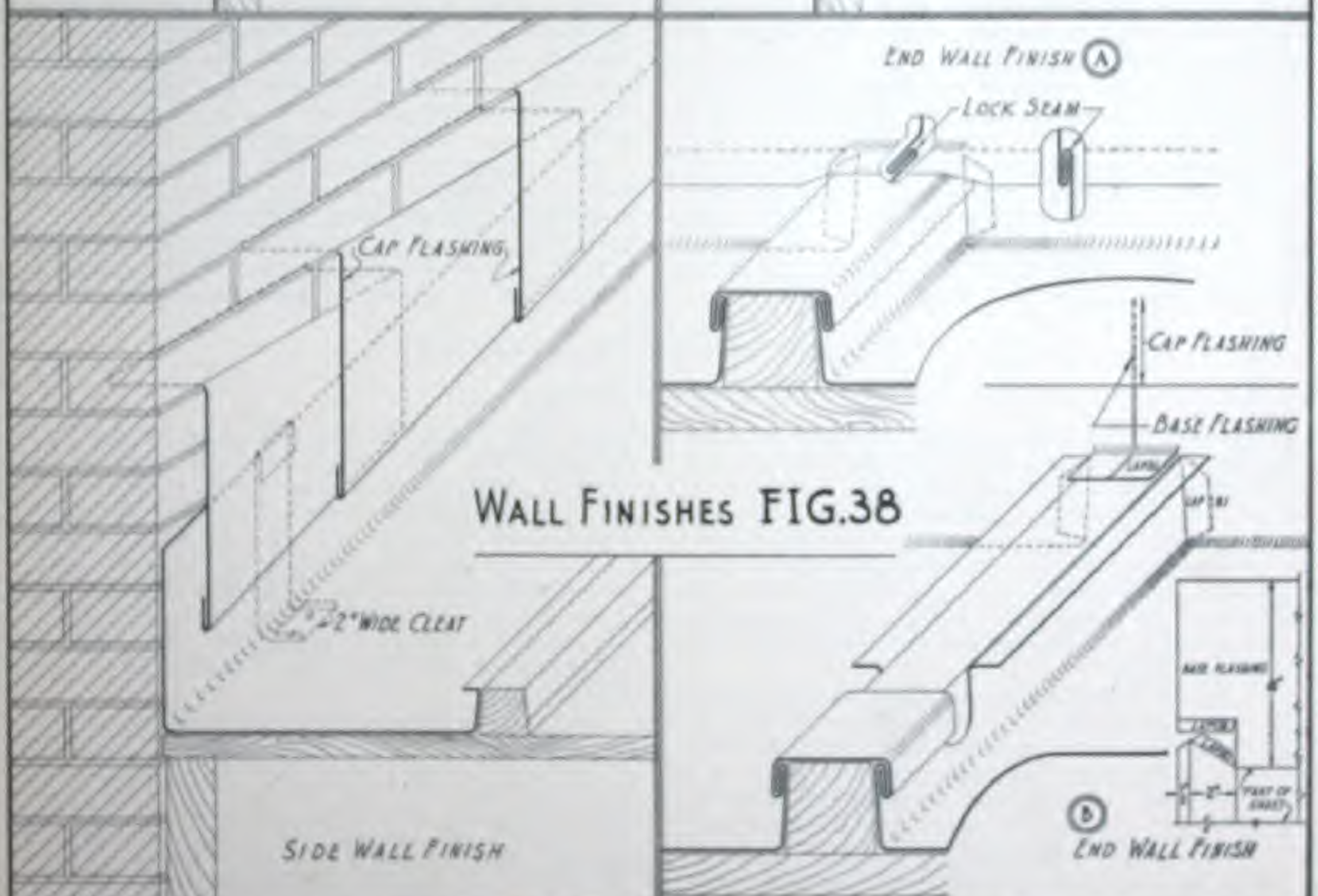
The method shown in Fig. 38B makes use of a cap and base flashing finish at the wall. The pan is cut as shown at the lower right, allowing it to be folded into the corner between wall and batten, and to extend up the wall 6″ as a base flashing. The lap (a), which is a part of the pan on the side of the batten, is folded in back of the base flashing and carefully soldered watertight. The lap (b) extends a short distance down over the batten, and is joined to a similar sheet from the other side by either a lock or a lap seam. The lap (b) is raised slightly from the batten to permit sliding the batten cap under it. After the batten cap has been locked in place to the flanges of the pans as usual, the lap (b) is soldered to it around the three sides, and the vertical joints between the upper end of the batten cap and the base flashing also are carefully soldered.

The cap flashing should be inserted in the masonry as described for the side wall finish, except that no stepping will be required, the flashing being installed continuously. Side laps between sections of the cap flashing should be at least 3″ and the cap flashing should lap the base flashing at least 4″.

In long roof runs a separate piece can be inserted to form the portion of the base flashing above and lapping over the battens. Such strips are flat-locked to the base flashing sheets on each side and soldered to the batten caps. This allows movement up and down the roof slope of the batten caps by not having them tied in to the base flashing, and at the same time the base flashing is broken with loose locks at each batten.



BATTEN ENDS AT GUTTER FIG. 37



WALL FINISHES FIG. 38

STANDING SEAM ROOFING

In standing seam roofing the sheets are joined along their long sides with seams left standing about an inch. These seams break up the roof area, avoiding the monotony of a continuous large expanse and give an attractive ribbed appearance, although less marked than in the batten type. In general, standing seam roofing is applicable to the same type of structures as the batten type, and can be used on smaller buildings more artistically.

Standing seam roofing can be laid on slopes as low as 2½" per ft., if properly applied. Since the standing seams are not soldered, they allow for lateral movement of the sheets, but are not leak-proof if water can build up over them. This might come about from ice and snow in severe climates.

SIZE AND SPACING OF SEAMS

Standing seams usually are made to finish 1" high. The spacing of the seams is a matter of design and architectural effect, but for reasons of economy a choice should be made which will call for copper sheets in stock widths—multiples of 2". Design using 20" sheets is recommended as optimum for general service.

SIZE OF COPPER SHEETS

For standing seams to finish 1" high, the sheets will figure 2¾" wider than the seam spacing. Accordingly, a sheet 20" wide would give a seam spacing of 17¼".

To make a 1" standing seam, vertical bends are made on the lengthwise edges of the sheets—on one side 1½" and on the other 1¼", the 1½" vertical bend on one sheet always adjoining the 1¼" bend on the adjacent sheet. Copper cleats, attached to the sheathing beneath the edge having a 1½" bend, engage the verticals, which are turned down and locked together. The seam so formed is again turned over, making a double lock. See page 11 for additional data.

If a ¾" finished seam is desired, the edges are bent up 1" and 1¼", respectively, and the seam spacing will be 2¼" less than the sheet width.

Standing seams never should be riveted or soldered, as this will not permit movement of the sheets. Cross seams should be left unsoldered if conditions permit.

METHOD OF LAYING

Figures 40 and 41 show methods of laying standing seam roofing. Sheets turned up at right angles, as described, are placed on the roof. Cleats 2" by 2½", bent as shown, are nailed to the sheathing 8" to 12" apart against the 1¼" bend of the sheets. The cleats are held with two copper nails and the ends are bent over to cover the nail heads. The last ¼" of the cleats is bent over to hold the sheets. The side of the next sheet having the 1½" bend then is put in place over and against the cleats, and the extra ¼" bent over, as shown. Finally, the top ¼" of the whole seam is folded over again through 180° to form a double-lock.

As in batten seam roofing, the sheets can be formed and handled by either the "roll method" or the "pan method", described on page 24. The cross seams are made ½" or ¾" and while sometimes soldered, preferably are left unsoldered if pitch is sufficient, as in batten roofing. Cross seams are staggered in adjacent bays.

It is important to consider the temperature at the time of installation, and make proper allowance for changes. In standing seam roofing, expansion can be allowed for by leaving a space at least ¼", at bottom of seam. This detail and adequate fillets are both important, but are not clearly shown in all drawings.

STANDING SEAM ROOFING DETAILS

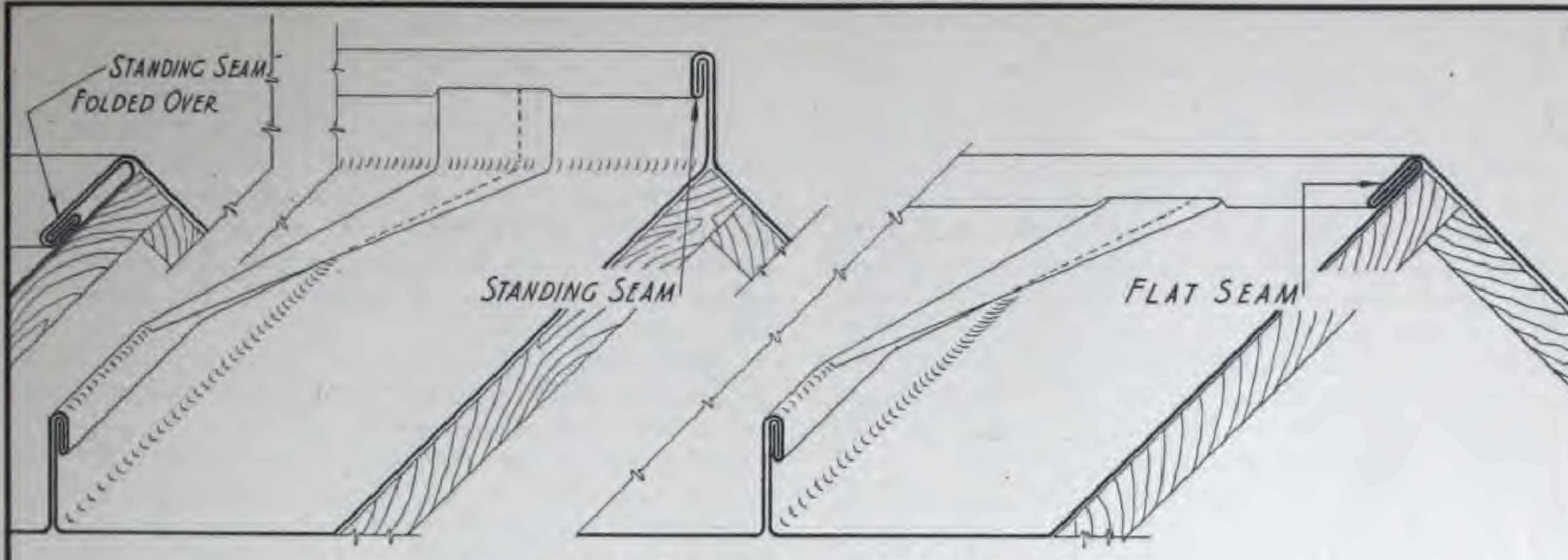
Ridges or Hips

Fig. 39 presents various ways of finishing the ridge or hip of a standing seam roof. The pans from the two sides can be brought up beyond the ridge, ¼" higher on one side than on the other, and a standing seam formed along the ridge. If desired, this seam can be folded down flat as shown on left. The standing seams of the roof slopes are turned down as they approach the ridge and folded into the ridge seam. Ridge and hip standing seams generally are finished the same height as those on the roof slopes.

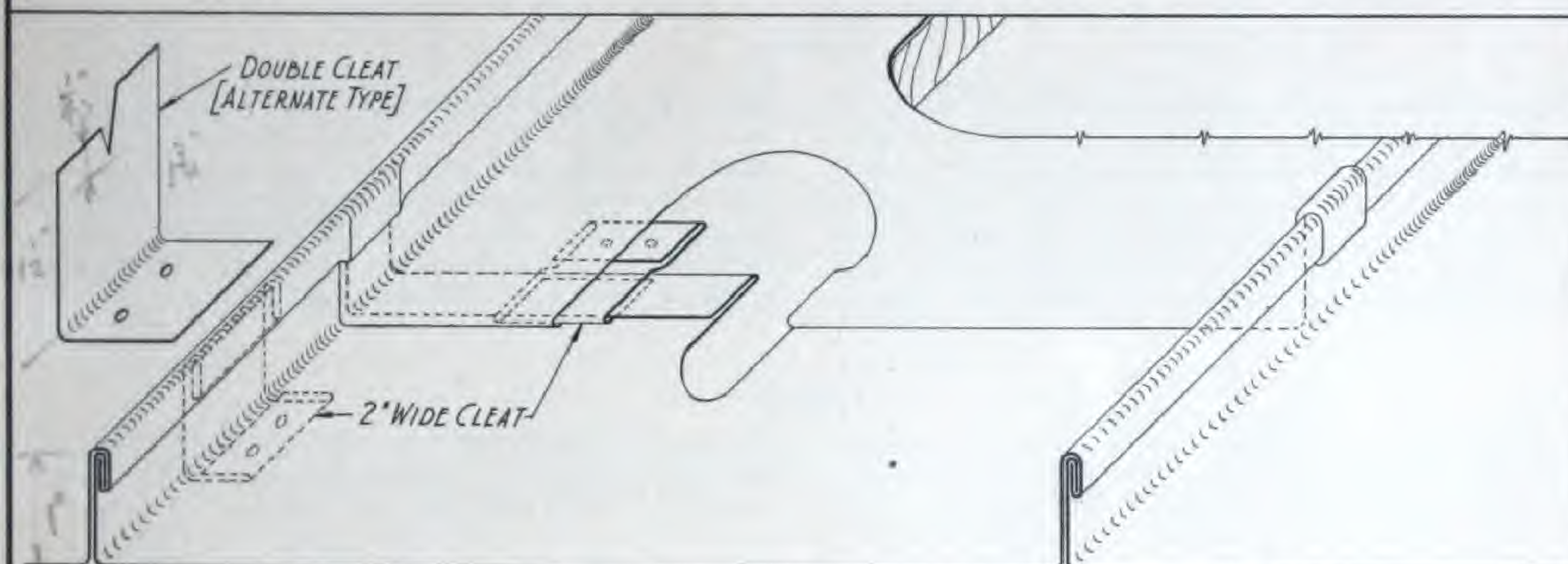
In place of a standing seam, a flat-lock seam can be used on a hip or ridge as shown on right of Fig. 39. Here the roofing seams are turned down flat in the same direction as the seams are formed and folded in with the ridge seam. On one side the flattened standing seams run into the ridge seam, and from the other they are carried over the ridge and down into the ridge seam.

Fig. 40 shows the application of a standing seam bay according to the method just described, with cross seams formed as in batten roofing. While the usual single cleat generally is used, a double cleat, as illustrated at the left, sometimes is employed. If the seam is to finish 1" high, the long side of the vertical leg of the cleat is 1¾" and the short side 1½" long, with ¼" notch in center. After the first roofing sheet, with the 1½" upturned edge, is in place, the cleats are nailed as described for the single cleat, and the extra ¼" folded over the roofing sheet, holding it in place. This is advantageous on an extensive job which cannot be completed at once. The other half of the cleat is folded in the opposite direction to engage the 1¼" leg of the adjacent sheet. The seam then is finished in the standard manner.

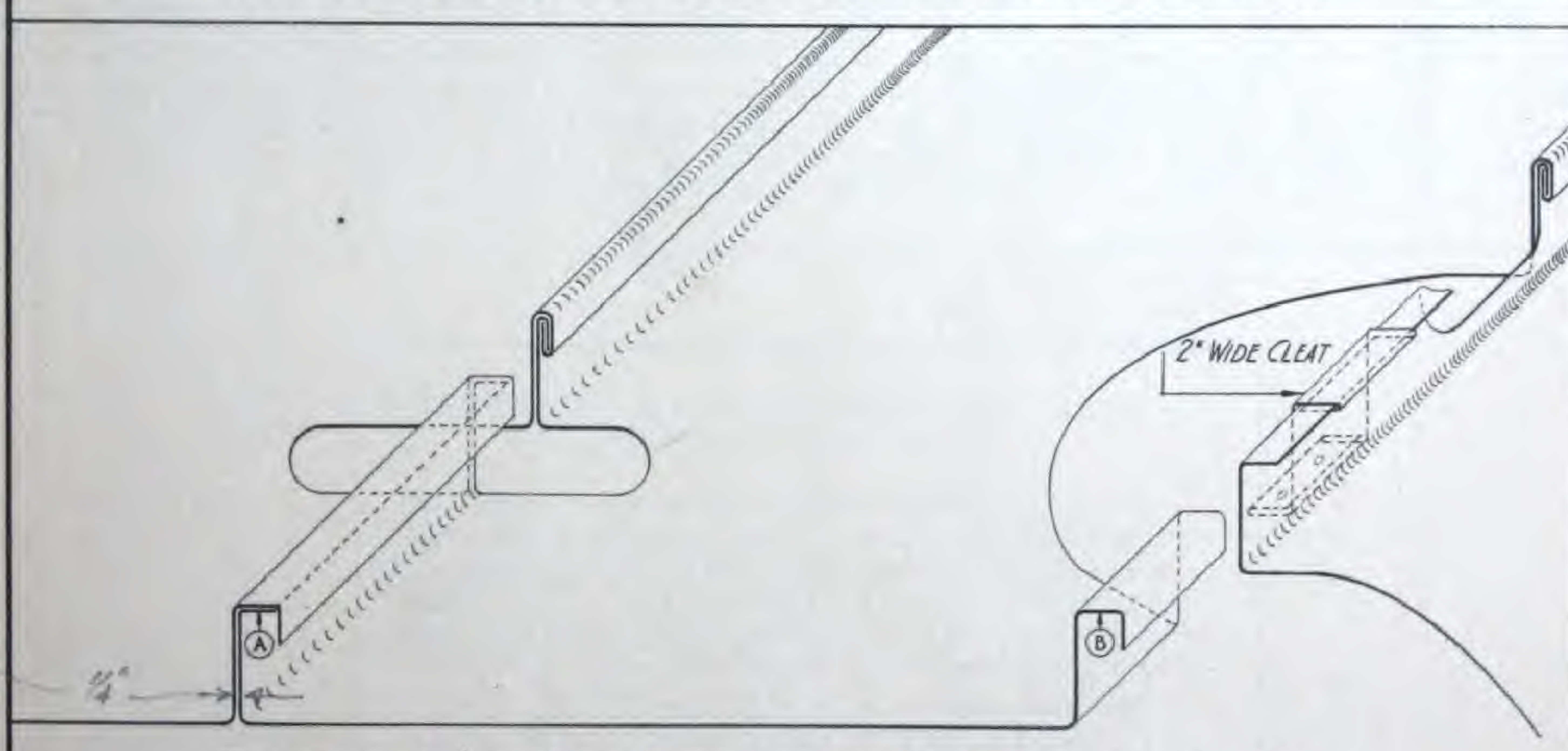
Fig. 41 shows another method of laying standing seams using sheets pre-formed in the shop. One edge of each sheet is folded twice, as at "A", and the other, three times, as at "B". The long legs of the folds are 1" and the short legs ¼". Each sheet is cleated along the edge with the "A" fold, as shown at the cutout, and the "B" edge of the next sheet laid in place over the cleats. The extra ¼" at "B" is folded up to 90° and the entire end finally turned down 90° to finish the seam. This method reduces work on the job and gives accurate and even seams.



RIDGE DETAILS FIG. 39



TYPICAL BAY-STANDING SEAM METHOD FIG. 40



TYPICAL BAY - PRE-FORMED PAN METHOD FIG. 41

Wall Finishes

Fig. 42 shows method of finishing standing seam roofing at a wall at top of the roof, using a cap and base flashing. The roofing is carried up close to the wall, with room allowed for cleating as shown. The base flashing is locked into the seam over the cleats and the standing seams are folded down, with the open side underneath, and carried into the flat-lock seam which is tack soldered. Another way of securing the base flashing is to use a longer cleat than shown in Fig. 42, so that the end of the cleat can be brought entirely through the locked seam and turned up on the outside of the base flashing. The base flashing should be carried up the wall at least 6″ and lapped 4″ by cap flashing.

The cap flashing is continuous, with side laps 3″ between sections, and the bottom edge is folded back 1½″ for stiffness. The cap extends at least 2″ into the masonry. If installed as the wall is erected, it should be anchored back of first brick. If placed after the wall is erected, it is fastened with lead plugs. (See page 36).

Detail 42A shows method of finishing standing seam sheathing of a vertical wall. The standing seams are carried to top of wall where they turn down and finish into the lock seam with wall capping. Such vertical sheathing can be used in place of the cap flashing at the right, when necessary to waterproof the entire wall above the sloping roof.

Detail 42C shows an alternate of the construction of 42B. The base flashing is locked into the cap flashing with a deep lock (at least 2″) as shown. This may be left standing out, as in the illustration, or flattened back against the wall. In either event the top of the lock should be from 2½″ to 3″ below the point where the cap flashing enters the wall, so that the base flashing can be locked into it in place.

Eaves

Fig. 43 shows various methods of finishing standing seam roofing at eaves and gutters. The standing seams are folded over (with seam opening on top) as they approach the eaves so they can be folded into the joint with the gutter or over an edge strip. The gutter lock can be placed on roof slope, as shown at the left, or at top of the inner side of gutter, as in Detail B. Gutter should be designed so its outer edge is at least 2″ lower than this seam which is left unsoldered to allow movement in the gutter lining. If there is no gutter a drip edge should be provided as suggested in Detail A. The loose-lock seam where roof and gutter meet may be filled with white lead to prevent water entering from capillary attraction. Do not solder.

Valleys

Fig. 44 shows standing seam roofing at a valley. The standing seams are turned down in the direction opposite to which they are folded, and together with the pans hooked into the valley flashing. The valley flashing is cleated as usual with 2″ cleats 12″ on centers with ends folded over the nail heads.

Gable Ends

Fig. 45 shows two methods of finishing standing seam roofing at gable of a roof. Detail A provides a drip edge to prevent wash running down the face of the building in case of overflow at built-up edge; and Detail B assumes a cornice at the end of the building. If the cornice is of considerable height it should be made of crimped copper, or, better still, built in sections locked together to permit expansion. The 2″ copper cleats should be spaced 8″ to 10″ apart. If desired, the end finishes for batten roofing (Fig. 35) can be used with this method as well as any of the plain edge strips illustrated in Fig. 89. The methods in Fig. 45, or Details 1 and 2 of Fig. 35 are best, however, because they provide curbs along the gable.

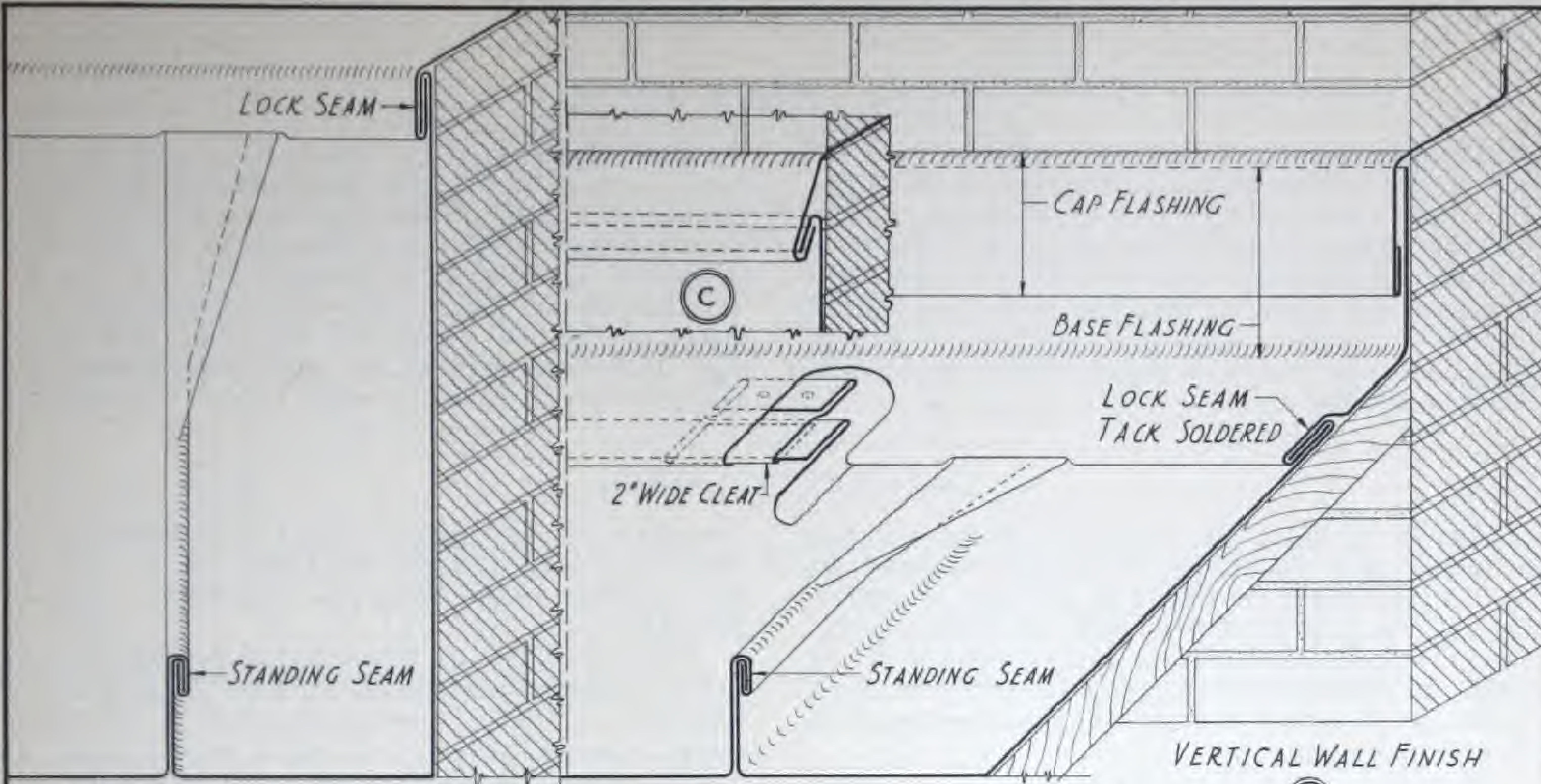
A NOTE AND SOME DON'TS ON STANDING SEAM CONSTRUCTION

Standing seam construction is, without doubt, the simplest and the best way to apply copper as a roofing material. Its use, wherever conditions permit, is strongly recommended. Most of the old copper roofs which count their life in centuries rather than in years are of this type of construction, where the use of solder is at a minimum.

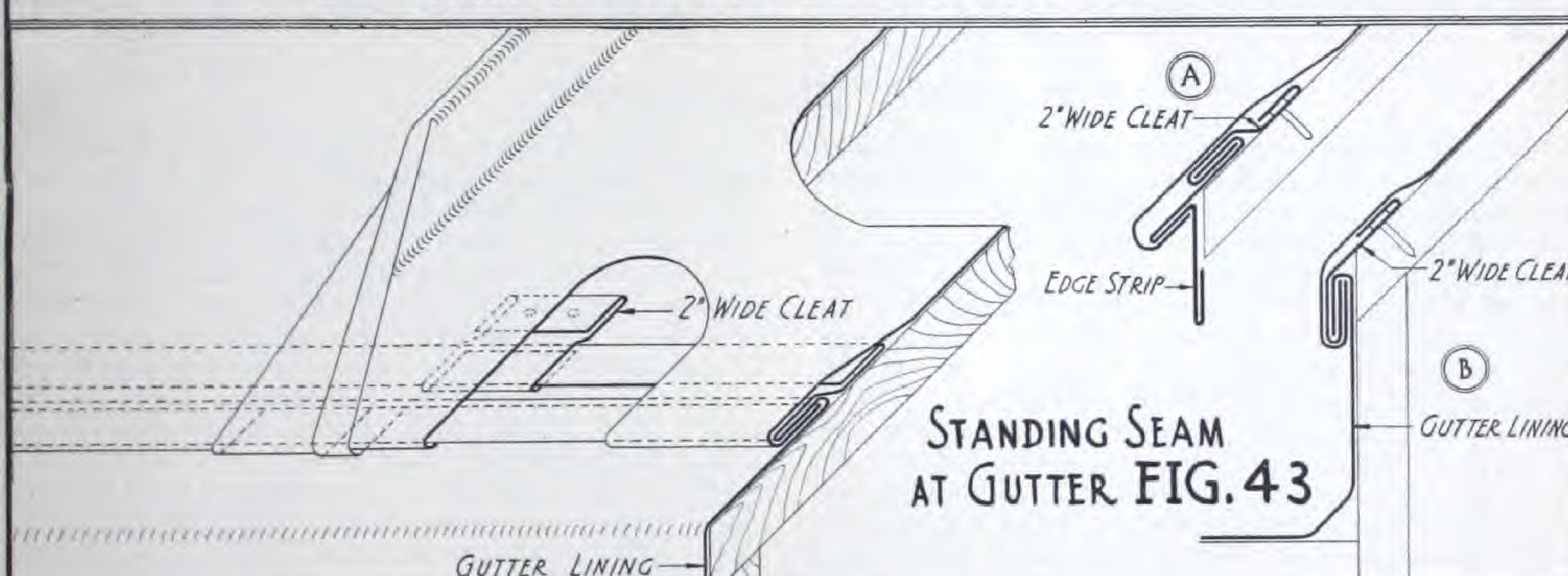
DO NOT solder cross seams. (See Fig. 40)

DO NOT solder standing seam areas to gutter linings. (See Fig. 43)

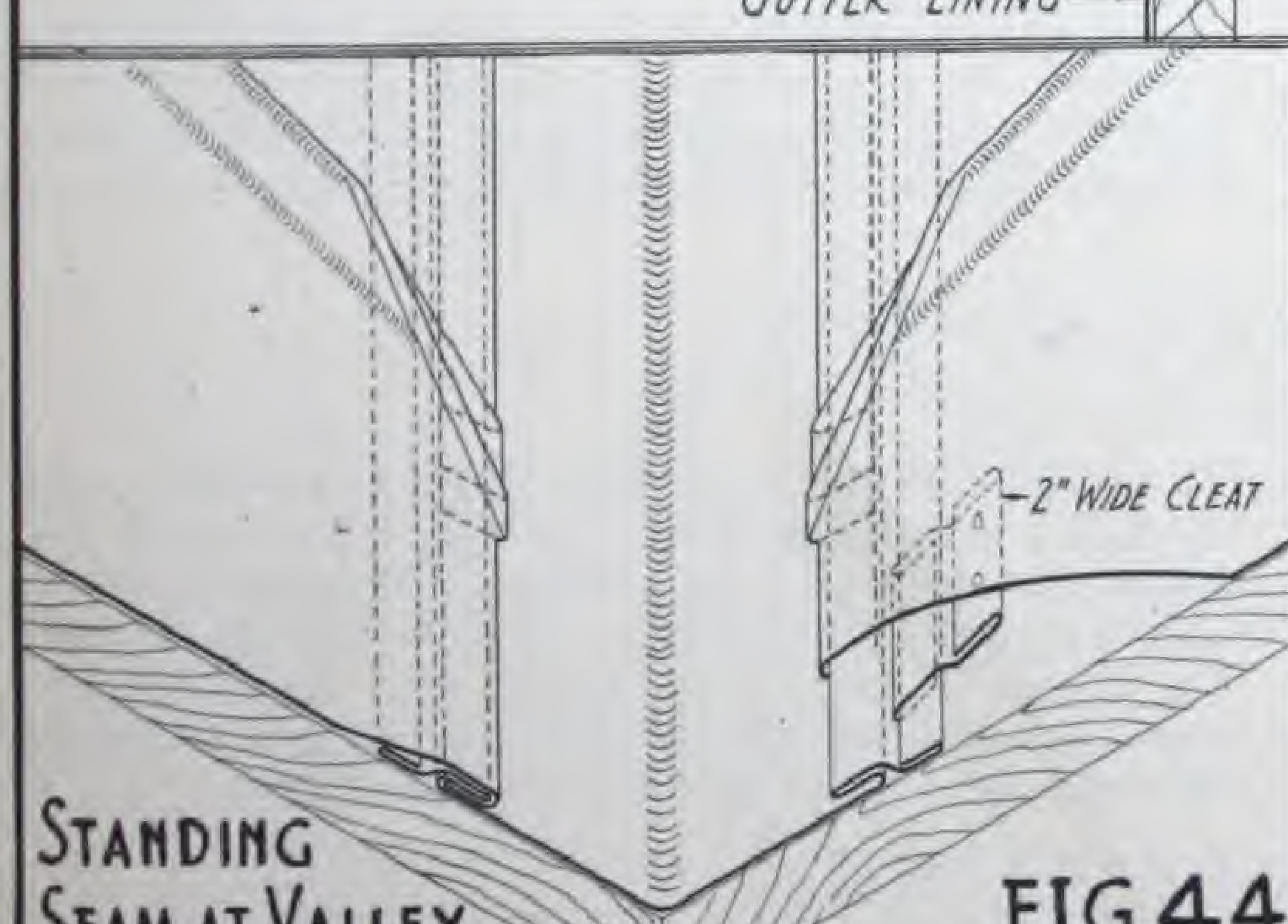
DO NOT solder standing seam areas to valleys. (See Fig. 44)



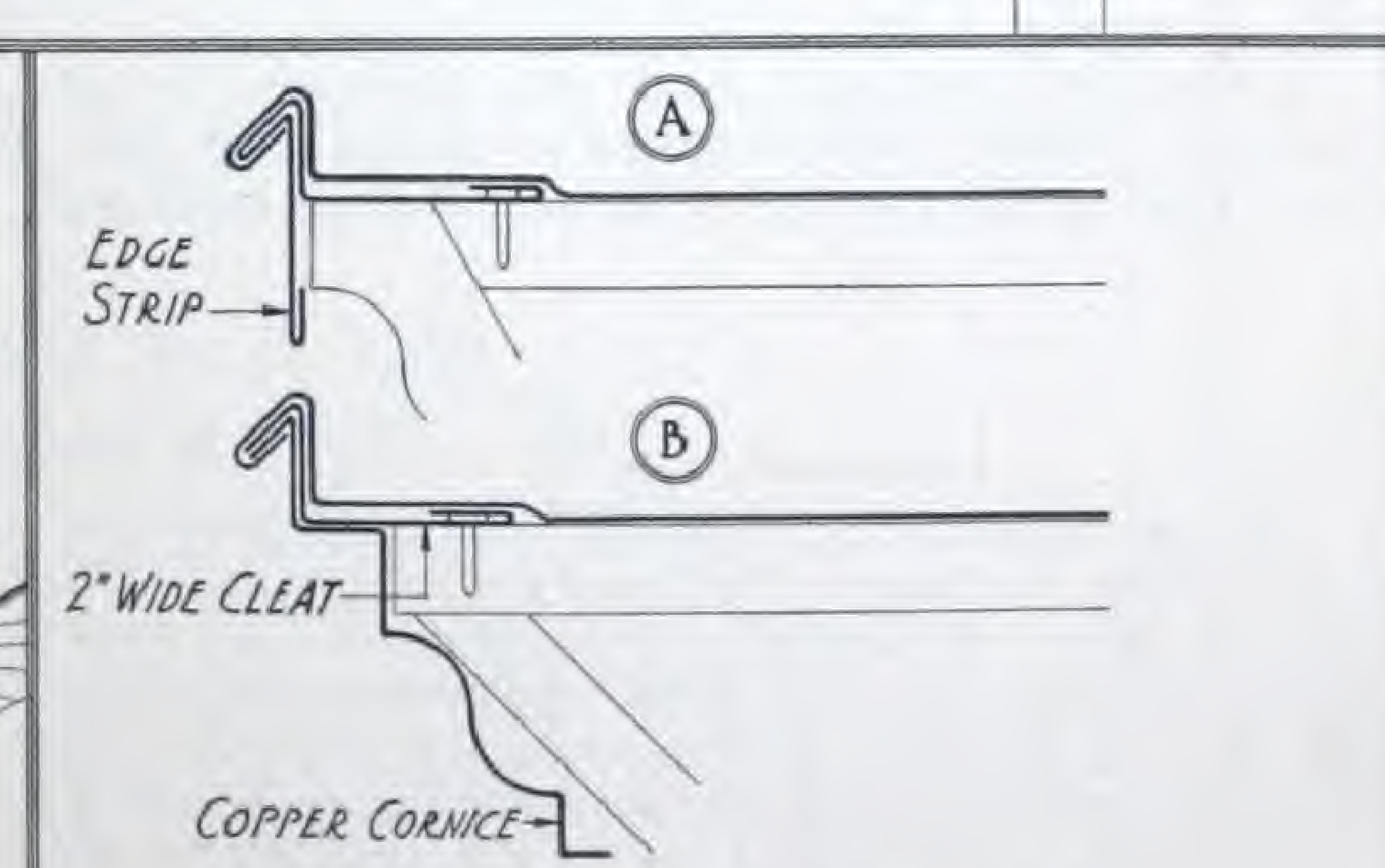
WALL FINISHES FIG. 42



STANDING SEAM AT GUTTER FIG. 43



STANDING SEAM AT VALLEY FIG. 44



GABLE ENDS FIG. 45

FLAT SEAM ROOFING

SIZE OF COPPER SHEETS

Flat seam roofing is used most commonly on flat decks or flat roof areas, but is adaptable to all slopes. Many very steep roofs, conical spires, towers, domes, and other curved surfaces are covered with flat seam roofing. It is necessary only that the roof and gutters have sufficient slope to shed the water. On curved surfaces the copper sheets are patterned in various shapes and sizes, and in all flat seam work large sheets should be avoided.

Small sheets, with ½″ seams, flat-locked and soldered, are used for flat roofs and decks. The size recommended is 14″ x 20″. These sheets are regularly stocked by the copper mills, with edges tinned for soldering. If there is no possibility of water collecting on the roof, because of clogged outlets, or ice and snow, the seams can be left unsoldered and filled with white lead. The sheets then do not need to be tinned, but this construction is rare, except on domes or steeples.

METHOD OF LAYING

Fig. 46 illustrates the method of laying a typical flat seam area. Additional information appears on page 10. The sheets are tinned on all edges, for soldering, and then are formed to lock ½″ with adjacent sheets. The corners must be properly clipped to permit folding, as shown at left. Opposite sides of the sheets are folded in opposite directions so they can hook into the next sheets properly.

The sheets are held to the surface by 2″ copper cleats. Usually two cleats hold one long side and one cleat a short side of each sheet. The other two sides are held by the edges of adjacent sheets already cleated. The cleats should be nailed close to the sheet and the ends folded back over the nail heads. Sheets with too few or poorly nailed cleats will not remain properly soldered.

The cross seams are folded in the direction of flow and it is of great importance that they be well sweated with solder. All seams should be flattened with a mallet before soldering, and then the solder sweated in to fill the seam completely. All flat enclosed roof surfaces, such as balcony decks, should have scuppers in the enclosing walls or auxiliary drains, so that water cannot back up if the main outlets become clogged.

EXPANSION AND CONTRACTION

Movement resulting from temperature changes is of special significance in flat seam work. In the batten and standing seam methods, where longitudinal seams are unsoldered, lateral movement between seams can take place if proper allowance is made at the time of laying. Movement in the direction of the roof slope in such construction also is cared for in various ways, such as loose cross seams where the slopes permit, special forming of the pans, and the strip pan method.

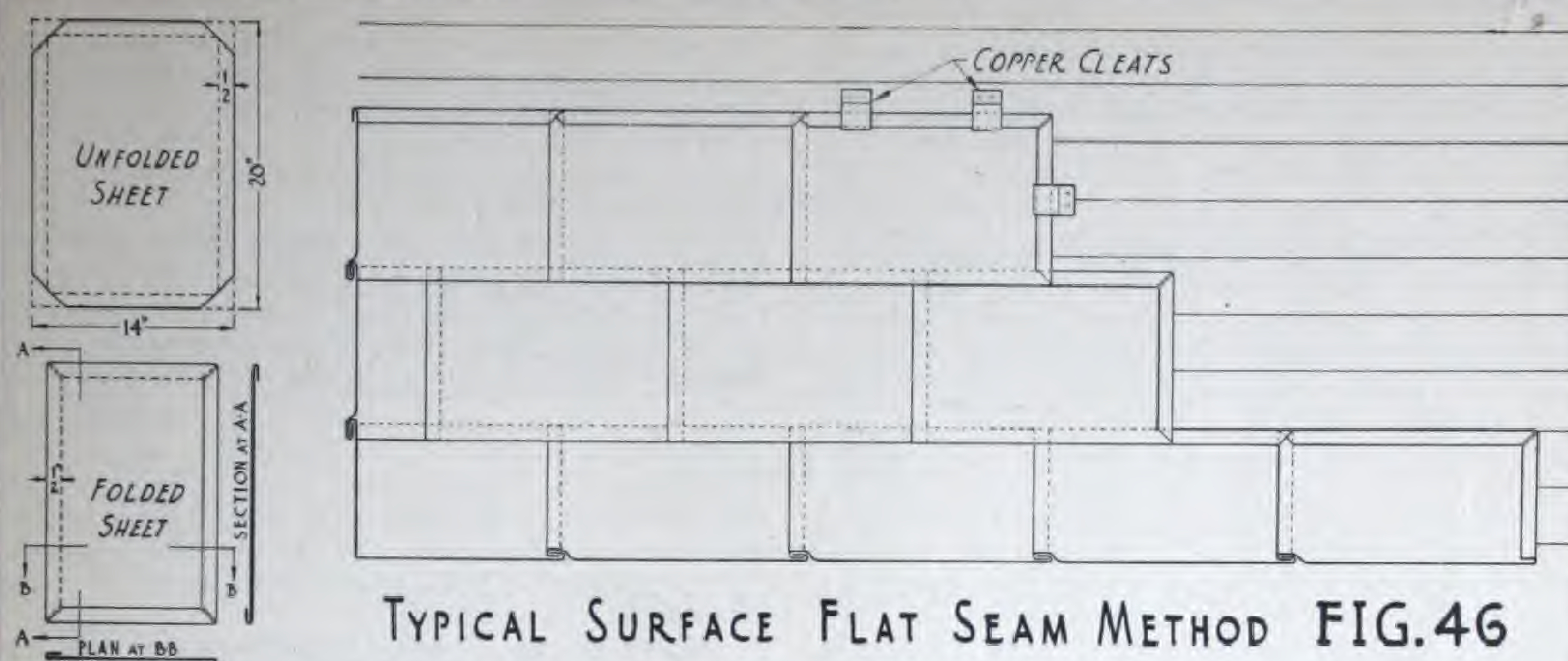
The flat seam method, however, does not allow free movement. The theory of the construction is that each small sheet is a separate unit through being cleated, and that the cleats prevent movement being transmitted over the entire area. Under expansion, each sheet puffs up slightly at the center. Under contraction, the cleats tend to prevent a total area movement being localized, but this is counteracted by the fact that each sheet is soldered to an adjoining one, thereby creating a continuous expanse of copper which is subject to general movement. Consequently, runs longer than 30′ to 40′ of flat seam soldered sheets should not be permitted unless the extremities are free. Large areas should be broken up with expansion joints, such as battens, as illustrated in **Fig. 47.** These run in the direction of the slope, and are covered with a copper cap, cleated down, to which adjoining roofing sheets are locked and soldered. The battens are shaped as in batten seam roofing, with bottom corners bevelled to permit the movement required.

If the run from ridge to eaves also has to be broken, steps or drops should be installed perpendicular to the slope. These should be sufficiently high to permit the roofing above and below to be joined with a vertical loose-lock seam on the face of the step. To prevent water entering, the seam is brought far enough above the lower roof area, or filled with white lead.

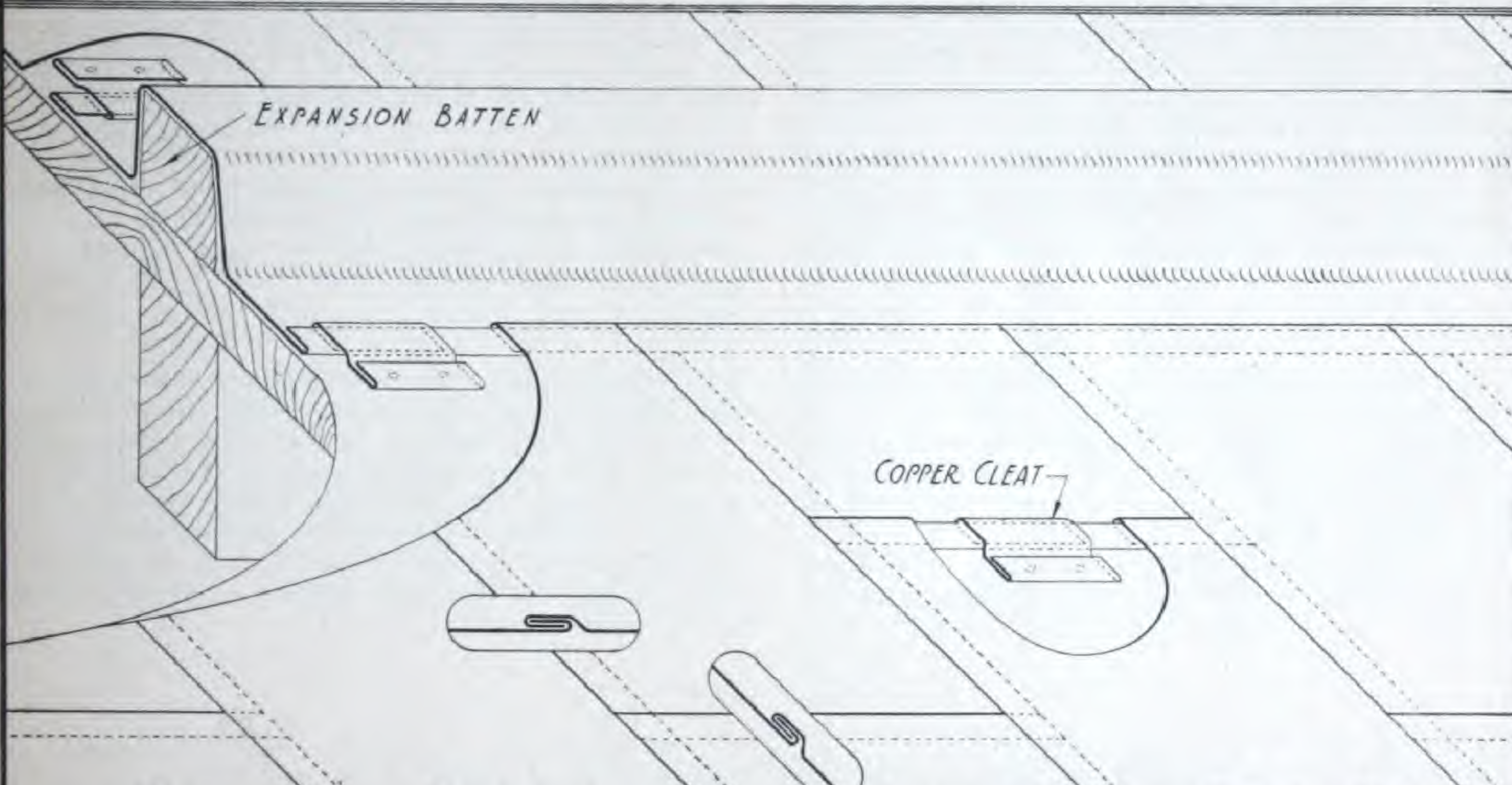
FLAT SEAM ROOFING DETAILS

Ridges or Hips

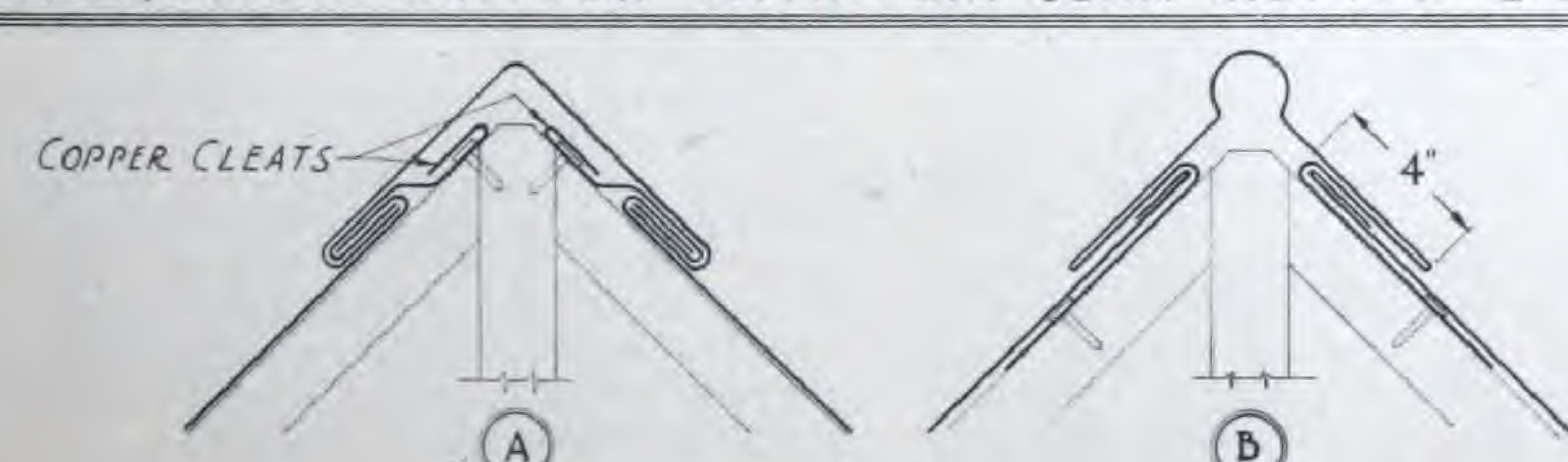
Fig. 48 shows two varieties of ridge finishes for flat seam roofing. In Detail A a flat copper sheet is folded over the ridge and cleated to the sheathing. The roofing is locked into the edge folds, and either soldered or left loose as dictated by the slope. If movement is required, the lock should be large enough to give the necessary lap, or a ridge piece of the type shown in Detail B should be used. This has a large crimp into which the top roofing sheets can slide. The edges of the sheets are folded back for stiffness. The lap is sufficient to give required safety. Other ridge finishes can be used. The details in Fig. 39 for ridges with standing seam roofing also are applicable with the flat seam method and are usual for the hips of flat seam roofing.



TYPICAL SURFACE FLAT SEAM METHOD FIG. 46



EXPANSION BATTEN WITH FLAT SEAM METHOD FIG. 47



RIDGE DETAILS FIG. 48

Gable Ends

For finishing flat seam roofing at gables see Figs. 35 and 45 where various constructions are shown, all of which can be used with flat seam work. Those with the edge built up have the distinct advantage of keeping the drainage on the roof at the ends of the building, and are recommended.

Valleys

Valleys seldom are encountered in flat seam work, and then are usually continuations over a depression of the flat seam construction. When a valley is to be formed of a continuous sheet in the usual way, the construction is similar to that for standing seam work, as shown in Fig. 44. The small roofing sheets may lock directly into valley edge-folds over the cleats. In the latter case, the valley lock often is larger than the lock in the roofing sheets. Then if left unsoldered, water will not fill the lock and get under the roofing sheet.

Wall Finishes

In flat decks it is common to surround the roof area with a wall or parapet on all sides. This also may include the low end of the roof, the water then being carried away by inside drains. The use of the cap and base flashing principle gives the best construction under such conditions. The roofing sheets are turned up against the walls at least 6″ and then lapped 4″ by cap flashings set in the masonry. On the side walls the cap flashings should be stepped from course to course as required by the slope; in most cases, as the slope will be slight, there will be considerable length of cap flashing in each course. In exposed locations with long runs it often is desirable to prevent the wind from lifting the cap flashings by inserting brass brackets or straps about 1″ wide and ⅛″ thick at intervals in the masonry, these extending down over the flashing. The cap flashings may be tacked with spots of solder at the side laps, which should be at least 3″.

Insert the cap flashings in walls as the masonry progresses. Except where through flashings are required to waterproof the entire wall, the copper sheets are usually carried into the wall 4″ and turned up ¼″ back of first brick. If flashings must be installed after the wall is erected, secure them with lead plugs about 1″ wide spaced from 8″ to 10″ apart, filling out the joint with elastic cement. To avoid cutting out mortar where flashings will come, use a sand course or wood strip which can be easily removed.

Wide Gutters

Flat seam roofing is very often used as an adjunct to either the batten or standing seam construction, for wide gutters, crickets, etc. Reference to built-in gutters has already been made on page 15 and considerably more detail on gutter construction will be found on pages 64 and following.

We would call particular attention here to the point that it is necessary to see that proper allowance for expansion and contraction is made in this type of flat seam work. As pointed out previously under Batten Construction and Standing Seam Construction, the connection between flat seam work and the other two types requires careful design and good workmanship. It should not be of such a nature that movement in one section of the roof is transmitted to the others. Wherever possible the connecting seam should be loose locked. If necessary the seam may be filled with white lead. See discussion of this at the bottom of page 21.

COPPER SHINGLES AND COPPER TILE

Copper shingles and tiles are made in a variety of sizes and designs. Some embody special features, and those interested should consult the individual manufacturers for detailed information. This Association will gladly furnish a list of these manufacturers upon application.

In general, the method of application is simple. Each unit is secured to the roof sheathing by copper or copper alloy nails, and laps over the adjoining ones, generally with a lock feature forming a watertight joint. No soldering is required. No special allowance for expansion is necessary as the form of unit provides room for movement.

Copper shingles and tiles are obtainable in different thicknesses, but they always provide a light-weight roof covering. Copper shingles can be laid over old wood shingle roofs, and are frequently used for re-roofing jobs. Both shingles and tiles are light in weight, fire and waterproof, durable, and pleasing in appearance. In common with all copper roofings, if properly grounded, a copper tile or shingle roof provides admirable protection against lightning.

VERTICAL SURFACES

Metals have been used on vertical walls and surfaces of buildings in some degree for many years. However, the use of copper has been restricted for the most part, until recently, to the sheathing of small items, such as parapets, and bulkheads, or for ornamentation, such as spandrels, mullions, and band courses. In the last few years a movement has begun, notably in Europe, for a much wider use of metal on wall exteriors. It has come to be realized that with steel skeleton construction, walls need be mere "curtains" to keep out the elements. Each floor is supported by the steel framework. Massive walls capable of bearing their own weight for the entire height of the structure no longer are necessary. Designers, accordingly, have turned to rust-proof metal, and have found that by using copper sheets with proper insulation, they can build a wall only 4″ thick with the same insulating qualities as a masonry wall 20 times as thick. It is obvious that great savings in space and weight result, and that with the adaptability of metal to factory fabrication, with ensuing large scale production and lower labor costs, the possibilities for further economies are vast.

The development of metal walls and all-metal buildings is still very new and nothing approaching standardization of construction methods has been reached. This Association makes every effort to keep informed on all new developments in this field and will be glad to furnish its latest information at any time.

FORM OF COPPER SHEETS FOR WALL SHEATHING

Corrugated, crimped, or flat copper sheets all may be used for sheathing vertical surfaces. Corrugated copper and its use for siding is discussed beginning on page 38. This type of construction is practical for structures such as factory buildings, sheds, and other commercial units.

Within the last few years there has been considerable progress made in adapting the use of copper to vertical surfaces. A number of excellent patented designs have been evolved. Some of these incorporate insulation details and are intended for general exterior construction of residences, etc. Others are designed to handle efficiently the flashing of the inside of high parapet walls. The Association endeavors to keep in touch with the latest developments in this line and will be glad to refer inquiries to manufacturers of these patented designs, from whom full information may be obtained.

Crimped copper frequently is used for sheathing the sides of penthouses, bulkheads, and similar enclosures on buildings. It usually is applied with flat-lock soldered seams. As described on page 20, it is well suited for vertical areas as the crimps aid in caring for expansion and contraction in the direction perpendicular to them, and the formation of locks with crimped sheets is not difficult on plane surfaces. Crimped copper nearly always is used in 16-oz. weight for sheathing, and the same rules of application apply as for flat copper. The sheets should *not* be nailed, as with corrugated sheets. Cross seams on vertical areas should be unsoldered.

The methods of applying flat copper sheets on vertical walls are the same as those for roofing, flat seams, standing seams, and batten seams all being applicable, although the batten type is not often used. Two examples of the use of standing seam sheathing are given in Figs. 42 and 82. The standing seams are folded down flat at the top and bottom to permit finishing and flashing. The flat-lock cross seams are left unsoldered for free movement. Sheets can be applied with flat seams in the same manner as in roofing and for small surfaces this gives good construction. For extensive walls, however, the standing seam method is recommended as it allows greater freedom of movement.

COPPER SPANDRELS

The use of copper and copper alloy spandrels has shown a marked increase in recent years. Building codes which previously discouraged their use by requiring heavy masonry backing, thereby nullifying their space and weight saving features, are being revised to permit their being backed with thinner insulation, provided the fire-resistant standards are met. There are notable examples of buildings already erected in which the wall space saved by employing metal spandrels instead of masonry has been used for concealed radiation under the windows, with corresponding increase in the rentable floor space of the building.

Because of its light weight, workability, and pleasing color, and because it is rustproof and does not require protection and upkeep, copper is an ideal metal for spandrels. It is used in cast alloy form, or as stamped or formed sheets. Many methods of manufacture and construction are current, but to date there has been no standardization of production or installation. Installations vary in size and in the weight of metal used. There also is a lack of uniformity in method of framing and connecting unit parts, as well as in securing them in place.

Cast units, which generally are heaviest and most expensive, usually are secured with angles fastened to the back of the spandrel and extending 3″ or 4″ into the masonry on each side. Spandrels also may be bolted to structural steel.

Sheet-formed units frequently are fastened to wooden battens with nails, screws, or cleats. Sometimes they are bolted to wood or metal brackets set into the masonry during construction.

Stamped sheet copper units, which are of comparatively recent origin, have been framed and braced in several ways, and in most cases are equipped with hooks or anchor bolts for securing them in place.

Much study and research now is being devoted to this subject. It appears that ultimately these building units may be developed in two types—(1) those stamped or cast, and backed, completely fabricated in the shop ready for installation, and (2) those stamped and framed for installation, but which will be filled with mortar or other material on the job after erection.

This Association will be glad to give advice to architects and sheet metal contractors on any specific problems relating to spandrels which may arise.

CORRUGATED COPPER ROOFING

METHOD OF APPLICATION

Fig. 49 shows the approximate dimensions of the standard "2½-inch" corrugated sheet as used for roofing and for siding. It will be noted that while nominally 2½", the actual width of corrugations is 2⅝". Sheets with a nominal corrugation of 1¼" are also available. This figure emphasizes again the distinction between "crimped" copper and "corrugated" copper, already mentioned on page 20. Actually both types are corrugated but the term "crimped" is applied to the closely-spaced, shallow corrugations as illustrated in Fig. 28-A. The term "corrugated" as shown in Fig. 49, is applied to the deeper, wider-spaced corrugations formed similarly to the corrugated sheets available in other metals.

As shown in Fig. 49, the standard construction for roofing is a sheet about 27½" wide (which before corrugation was 30") laid with a lap of one-and-one-half corrugations. A two-corrugation lap may also be used, providing alternate sheets are turned upside down. The coverage in this case is, of course, correspondingly decreased.

For siding the standard sheet is about 26" wide (28" wide before corrugation). This is laid with a single corrugation lap, so the actual coverage for both roofing and siding is 24" per sheet. The end lap for roofing should be at least 6"; for siding 3".

All copper corrugated sheets and accessories should be secured with fastenings of copper or copper alloy. In roofing, these are applied through the highest points of the corrugations. Copper alloy nails 8" apart with lead washers are used for securing these sheets to wood sheathing or purlins. If the copper sheets are to be laid over steel purlins, the purlins should be insulated from the copper with lead or felt strips. Many types of fastenings have been developed, such as clinch nails, clinch rivets, straps, etc., for this kind of construction.

Corrugated roofing always should be laid starting at the end of the roof farthest from the direction of the prevailing wind. This will allow lapping the sheets away from the wind, decreasing the danger of rain driving under the sheets.

Eaves

Fig. 50 presents one method of treating corrugated copper roofing at eaves, the eave being flashed to the siding. The roofing sheets project 2" or 3" beyond the edge of the roof. The flashing piece extends up under the roofing about 2" and is nailed. Under the roof projection the flashing is crimped to form both a drip and a pocket to receive the top of the corrugated siding. The lower end of the flashing unit is nailed to the wall sheathing before the siding is applied. Often the flashing is omitted if the wall is not sheathed with metal.

Ridges

Fig. 51 shows a method of finishing corrugated copper roofing at ridges. Separate ridge units are required. A plain ridge cap is used in which the corrugations flatten out as they approach the ridge until the metal is entirely flat at the peak. The ridge pieces are nailed to the sheathing with copper alloy nails, using lead washers, and the spacing is 8" through the top of alternate corrugations (see Fig. 50A).

Gable Ends

Fig. 50A presents one method of finishing a gable end. A batten along the edge keeps the drainage on the roof, the roofing sheets being cut so they lie against it almost to the top. The edge flashing acts as a cap flashing over the roofing and locks to the cleated flashing piece below to form an edge drip. If required for security, nails can be driven through the lap joint into the batten. The vertical siding fits into the pocket formed in the flashing, and is secured with copper alloy nails and lead washers spaced 8" on centers in the valleys of alternate corrugations. If the gable overhang is large, and stronger construction is required, a brass edge strip can be used as described on page 62 and illustrated in Figs. 87 and 89.

Siding Corners

Figs. 50B and **50C** show methods of finishing corrugated copper siding at external and internal corners, respectively. Corner units of copper, formed with pockets to receive the sides of the sheets are nailed to the wall. These units are installed before the siding is erected.

Wall Finishes

Fig. 52 shows a method of flashing corrugated roofing against a wall at the top. Under a standard cap flashing a specially formed piece extends at least 6" up the face of the wall and an equal distance down over the corrugated roofing. If necessary, mastic can be filled in to make the construction watertight.

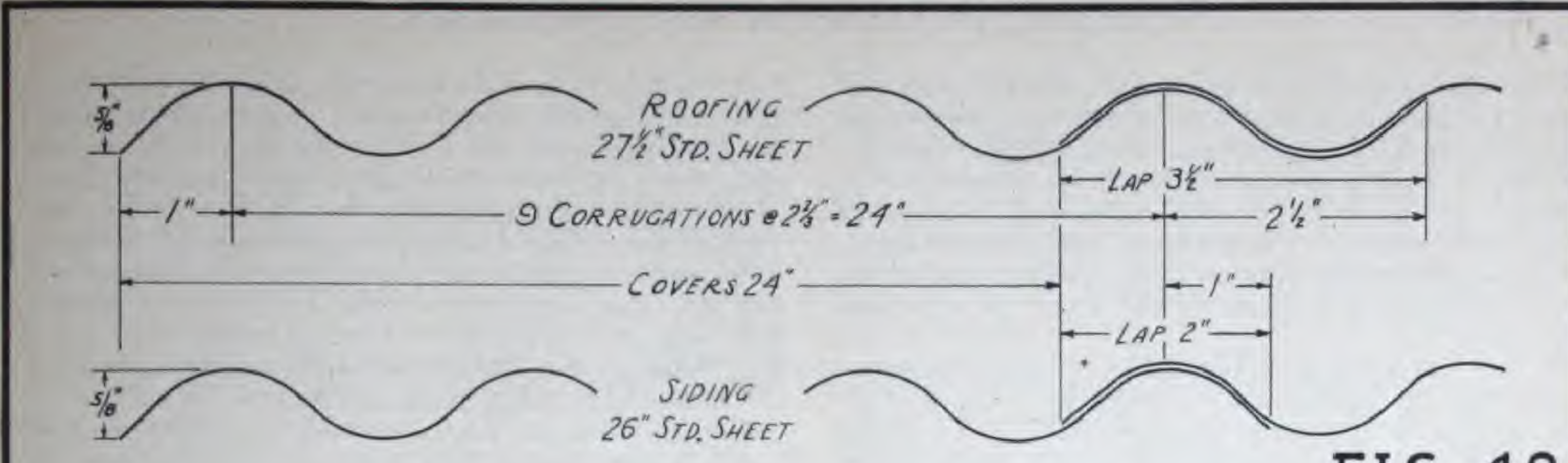
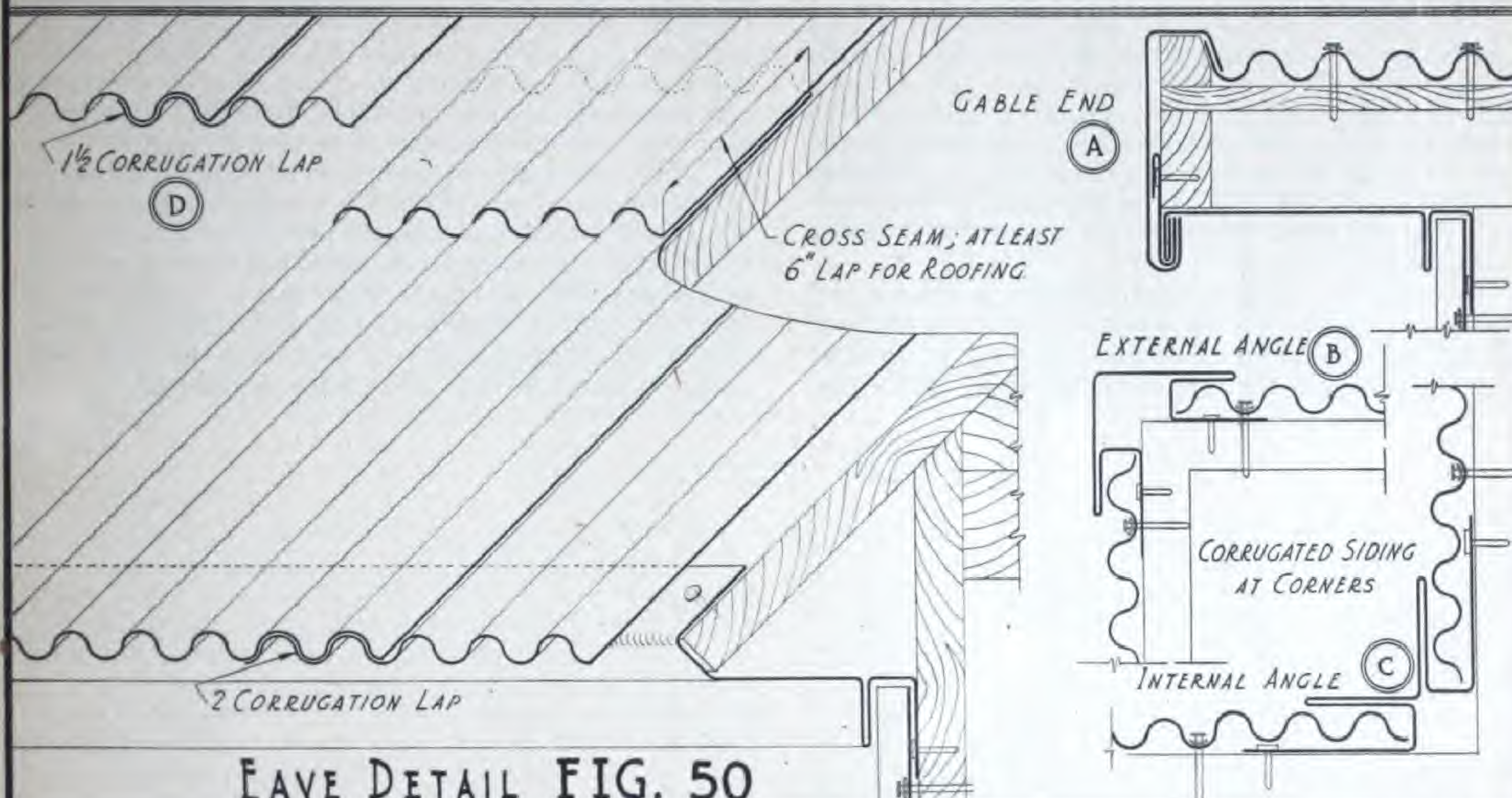
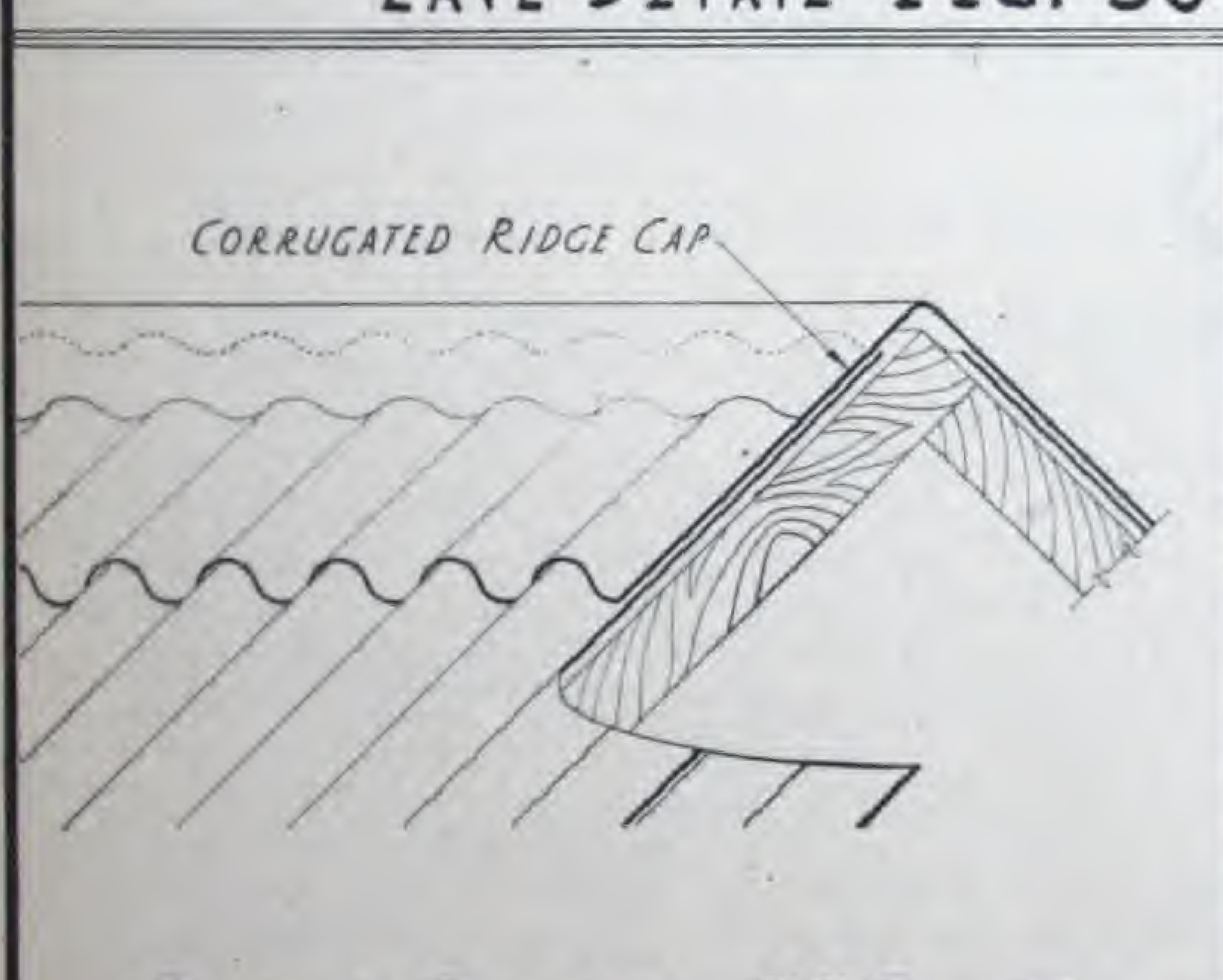


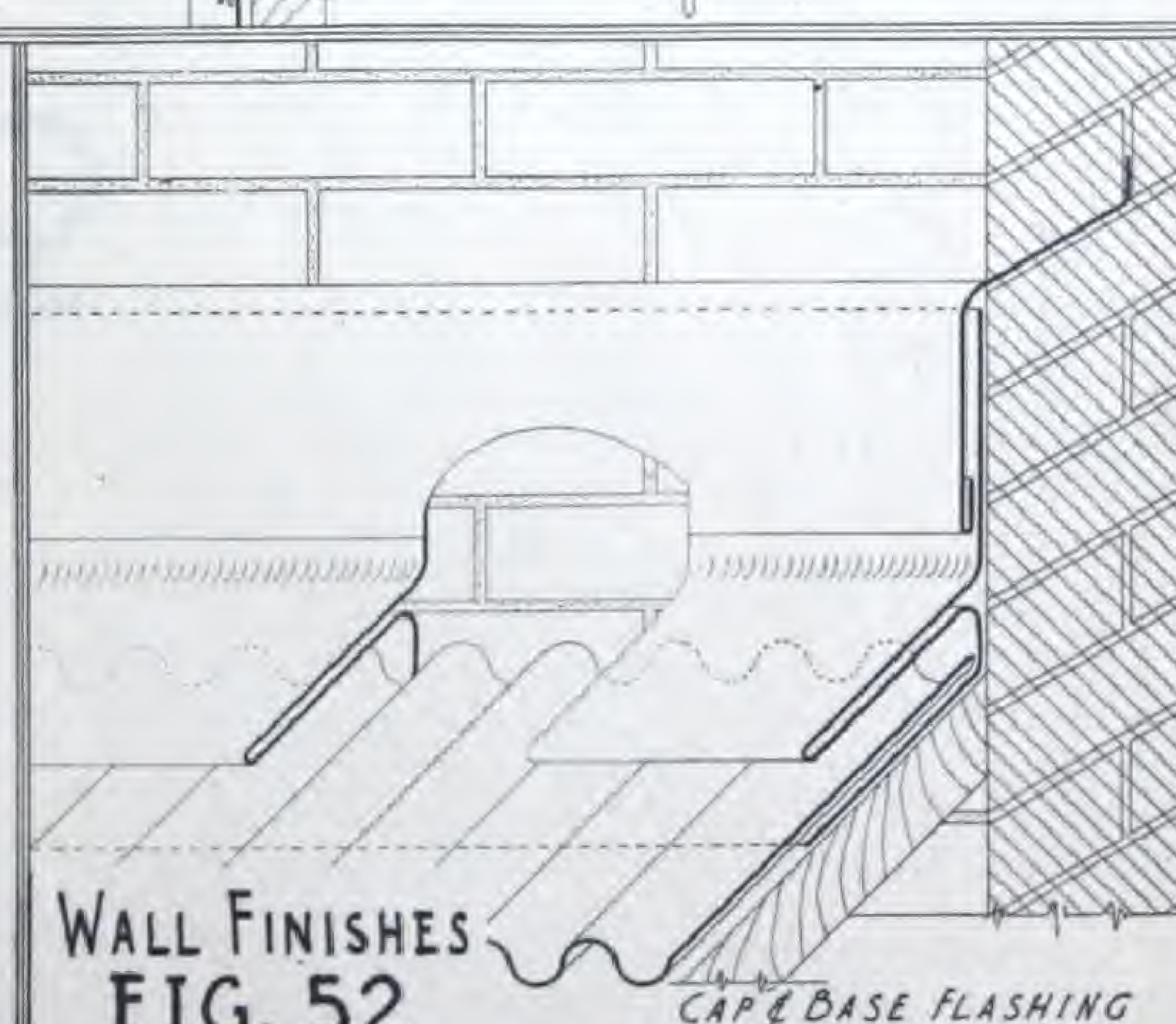
FIG. 49



Eave Detail FIG. 50



Ridge Detail FIG. 51



Wall Finishes FIG. 52

SPIRES, DOMES AND TOWERS

Special forms of roofing, such as spires, domes and towers, should be designed after full consideration of the special features involved, but the main principles of sheet copper application should be adhered to in every case. Neither the architect nor the competent sheet metal contractor should have difficulty with particular installations. However, this Association will be glad to give advice, if called on to do so, in individual instances.

There are many possible forms of domes and spires. These usually are covered with copper because of its lasting qualities. Freedom from deterioration over long periods is very important for such installations where expensive scaffolding is necessary for repairs.

The standard methods of copper application all are suitable for covering spires, domes or towers, and the decision of which to use will depend upon the architectural considerations and the specific features of the case in hand. For instance, on a small dome, the batten method probably would not be artistically appropriate or easy to apply because of the sharpness of the curvature. The flat seam method could be used with entire satisfaction.

In using the batten seam method on towers and domes, rib spacing should be worked out carefully so all bays will be identical. A single pattern can then be used for cutting the sheets of all the bays. These patterns usually are made of roofing paper or galvanized iron with proper allowance for seams. Cross seams may be staggered, and if this is decided on it is advisable to lay out two sets of patterns for alternate bays. Where curved or double-curved surfaces are to be covered, the size of the sheets should be limited to cover an area which departs only slightly from a flat surface. On very sharp curvatures difficulty is encountered in forming the battens, and in keeping longitudinal seams from binding, so it is better to use flat seam construction.

In laying standing seam roofing, the considerations are much the same. The correct spacing of longitudinal seams is important in eliminating waste and permitting the use of single patterns for adjacent or alternate bays. Here, too, the cross seams may be staggered. On curved surfaces short sheets should be used. Sharp curves cause excessive stretching or crimping and render the standing seam method impractical. Accurate patterns should be made with proper allowance for seams.

Flat seam roofing is applicable to virtually all styles of domes and towers. As in flat roofing work, it is best to use small sheets. On domes the sheets usually vary in size from one course to the next, but those in any one course generally are made from the same pattern. If they are laid in horizontal rings, the vertical joints should be staggered. Sheets also may be laid with diagonal seams, if that effect is more desirable.

SECTION III—FLASHING

In both the roof and the walls of a building there are many places where joints must be watertight. Sheet-metal protection—flashing—is best for this purpose.

Joints where one roof surface intersects another to form a valley, at gutters, and where parts of a building project above or through the roof, such as chimneys, dormers, vents, etc., are the great source of possible trouble from leaks.

The paramount purpose, naturally, of the whole roofing, flashing, and drainage system is to shed water and carry it away from the building quickly and efficiently. Valleys and gutters are not to be catch-basins or reservoirs, but channels to lead water away. Wall flashings should be designed and placed so as to turn all water and moisture to the outside face, where additional means of drainage should be provided.

Leaks in flashings may be caused by breaks in material due to corrosion or mechanical failure, or to defective protection of the joint. The general acceptance of copper by the building industry as the best metal for flashings and accessory parts is due to its many fine qualities, including lightness in weight, ductility, ease of handling, and the fact that it resists corrosion.

But no matter how good a material may be available for a given purpose, if it is misused it cannot perform with satisfaction. Copper, as well as all other materials, must be used properly if it is to give the fine service of which it is capable.

FLASHINGS FOR ROOFING TILE

Roof tile is made of terra cotta and of concrete in a variety of designs. Terra-cotta tile has been used for centuries. Concrete roof tile similar to terra-cotta has been put on the market recently.

Tile roofs require special treatment at flashing points, due to the shape and design of the tile. The flashings generally are made of larger sheets than those used with other roofing because of the need of covering joints near the flashing points, and of conforming to the irregularity of the construction. (See Fig. 90.)

The use of 20- or 24-oz. copper is recommended for roof tile flashing. This added thickness better withstands the wear incident to heavy tile, particularly Spanish tile, where the shape causes drainage to strike the flashing in concentrated streams.

The principal rules for roof-tile flashings are:

(1) Use sufficient copper to cover the joints at flashing points.

(2) Apply the copper loosely, so that heavy tile will not hold it too tightly or cut it.

(3) Fasten as little as possible; let sheets be held in place by the weight of the tile.

FLASHINGS FOR STONE WORK

If copper is applied directly to light-colored building stone or marble the consequent sweating or condensation on the under side may cause discoloration. To avoid this, waterproof paper or felt should be laid under the copper, thus preventing direct contact.

With some light-colored stones, such as marble or limestone, lead-coated copper works out admirably for flashings and the possibility of run-off stain is avoided. This material is discussed on page 19.

The design also should provide that possible wash from the metal does not flow over the face of the stonework. This rule applies to any type of roof, for dirt collecting on a roof makes such wash objectionable. This can be overcome by draining the stonework inward except for the small portion beyond the outside reglet.

Good practice in stonework, with parapet and other walls faced with stone, calls for reglets rather than for step flashings in the joints. The reglet is cut straight or at an angle across the stone as occasion may demand.

Many experienced stone setters consider lead wedges and lime mortar the best method of filling reglets. The objection is the necessity for frequent repointing. Lead wool or molten lead do away with this consideration. Page 70 gives data on reglets and caulking.

FLASHINGS FOR TERRA COTTA

All built-in flashings should be furnished and installed by the sheet-metal contractor. All built-in sheets should be shaped by the sheet-metal worker to conform to the measurements furnished by the mason setting the terra cotta, with sufficient metal left to allow proper connection to adjoining flashing. These built-in flashings, in the majority of cases, are counter-flashings.

The best method of fastening flashings to the blocks is shown in Fig. 103. Holes for plugs about 3/8″ diameter are formed in the terra cotta 8″ or 9″ apart. A small piece of sheet lead is rolled around a large nail, this hollow cylinder being inserted in the hole and a brass screw turned through the copper into it. The lead fills the hole completely and makes a firm anchor.

Wooden plugs are not suitable, for there is danger of splitting the terra cotta in driving them and dampness is liable to cause them to swell.

The drawings that follow will show there is one principle entering into the erection of terra cotta: viz., to make as complete a cut off as possible so moisture driving at open joints, etc., cannot work into the interior of the building. This should control the design of terra cotta construction and the provision of proper flashings, which, consequently, as nearly as possible, should be continuous and placed to provide complete waterproofing of the interior.

Balconies, balustrades, rails, copings, etc., require keying to hold them in place. It is not easy to get the flashing material over the key if it is made exactly to dimension as drawn. As it is necessary that the copper be well fitted so the super-imposed pieces have a good bearing, the key should be made slightly rounded and shaped with mortar to fit the flashing strip. (See Figs. 101 and 105.)

The use of brass and other copper alloys for bars and anchors, and of copper wire in this work, is increasing and is strongly recommended. This adds slightly to the cost of first installation when compared with rustable fastening, but insures a permanent job, requiring no further attention.

FLASHING DETAILS—METHODS OF INSTALLATION

There follow a series of standard flashing details, in the form of drawings and notes on recommended practice in copper work. For certain details used in connection with batten seam, standing seam, flat seam, and corrugated roofing; reference should be made to the data under those headings in the Roofing Section.

RIDGES AND HIPS

Fig. 53 shows four types of hip or ridge flashings. The methods are to a large extent interchangeable. For instance, copper or copper alloy straps as shown in Detail 2 can be used with any of the other methods.

A low ridge-flashing without a projecting roll can be made as shown in Detail 1. The ridge boards covering the shingles are secured to the roof by nailing to blocks placed at intervals on the sheathing (the shingles being cut to fit around), or on a continuous block formed of ⅞″ strips. After the shingles are laid the ridge boards are placed over them as shown, and are covered by the flashing piece. This is secured to the edge of the ridge boards by nails, as shown, or by brass wood screws. The flashing has a slight projection (about 1″), which is bent down to the shingles after nailing. This sheds the water and covers the nail holes.

The method shown in Detail 2 requires a specially shaped ridge-piece to take the flashing roll. The roll is secured by screws in the sides as shown, and the apron, if more than 4″ wide, should be stiffened against wind by 3/16″ x 1″ copper or copper alloy clamps or straps, about 30″ apart. These straps are secured by screws through countersunk holes as indicated, or are soldered to the apron. If placed under the apron they are riveted to it before the piece is set.

The method shown in Detail 3 requires no special shaping of the ridge-board, and is an excellent way of securing a large ridge roll. The board keeps the metal in place and is set so the roll can be fastened by screws to the ridge-board, making it unnecessary to drill the shingles or slates.

Detail 4 shows a simple method of finishing a ridge by the use of stock ridge rolls. These are made of hard (cornice temper) copper up to 3″ roll and 3½″ aprons. They are fastened with brass screws set through lead washers into holes drilled in the shingles or located above their upper edges. They require no ridge board. The screw heads should be soldered if no washers are used, but good practice calls for screws and washers with over-sized holes, to allow for movement, and covered with small copper caps as in Fig. 118.

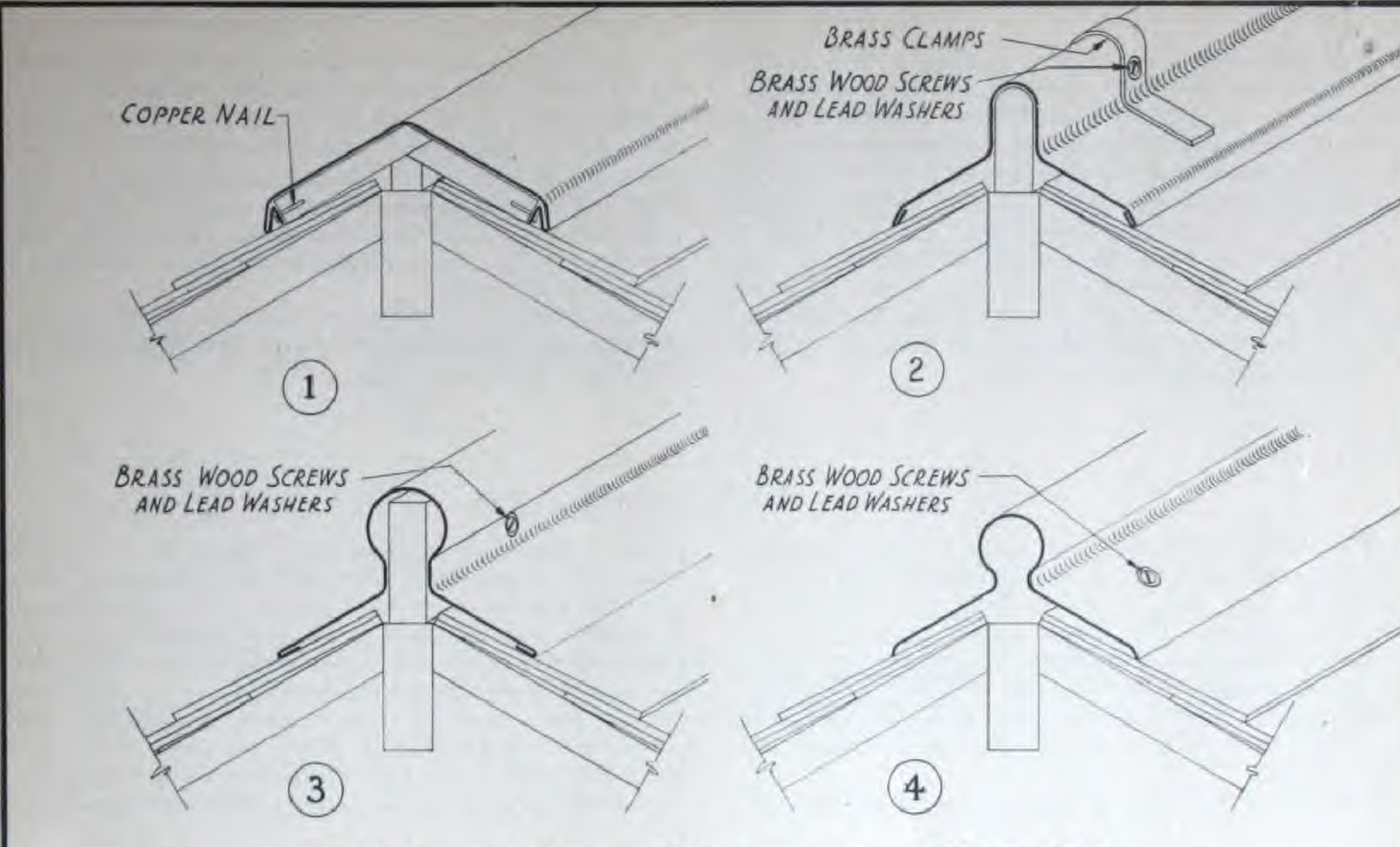
Fig. 54 shows the use of small pieces of copper built in with the shingle courses on hips to prevent water working under the edge of the aprons and thence under the shingles. Each flashing is hooked over the upper edge of the shingle upon which it rests, and extends to within ¼″ of the butt of the shingle lying over it. The copper ridge piece is placed last, and has an apron on each side to cover the nail heads of the uppermost course. It is fastened to the wooden hip pole with clamps as shown in Detail 2 of Fig. 53.

Fig. 55 shows method of flashing a hip or ridge of a shingle roof without a metal ridge roll. The roof is covered as usual up to the wooden nailing strip running along the ridge or hip. As the shingles covering the hip are laid, copper flashings, cut with tabs at the top edge as shown on the upper flashing, are placed between each course to cover the nail heads. The flashings are cut to extend almost to the butts of the shingles covering them, which means that with a shingle lap of 3″ the flashings will lap each other almost 3″. They are held in place by folding the tabs over the top edges of the shingles upon which the copper sheets rest. In the finished job the flashings are concealed.

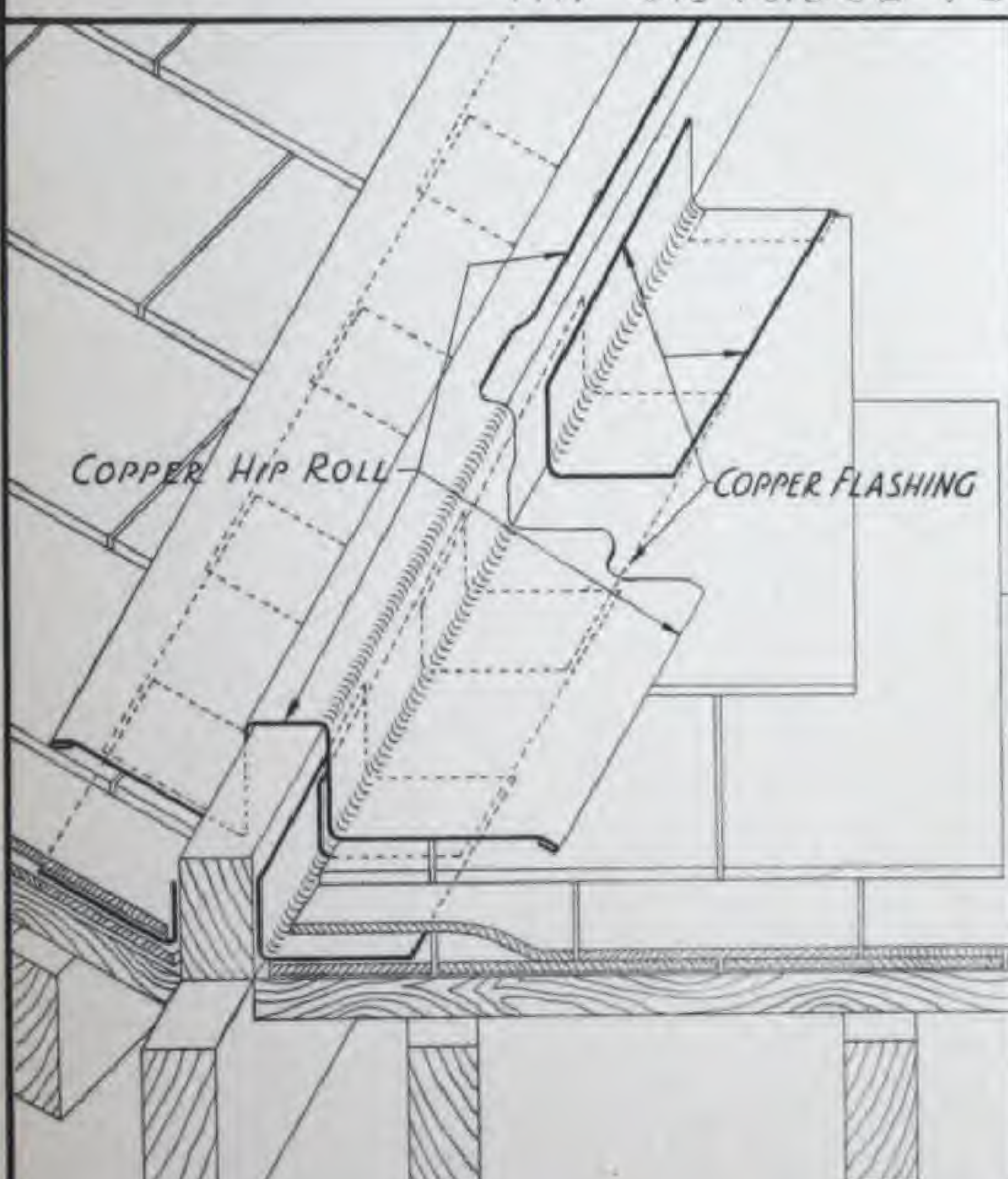
Other special cases, such as saw tooth ridges, are treated in the same general way. Many forms of ridge rolls are on the market and the procedure already outlined should govern their installation. Elaborate ornamental rolls, however, require special bracings and fastenings, and each case should be specially considered.

LONGITUDINAL MOVEMENT

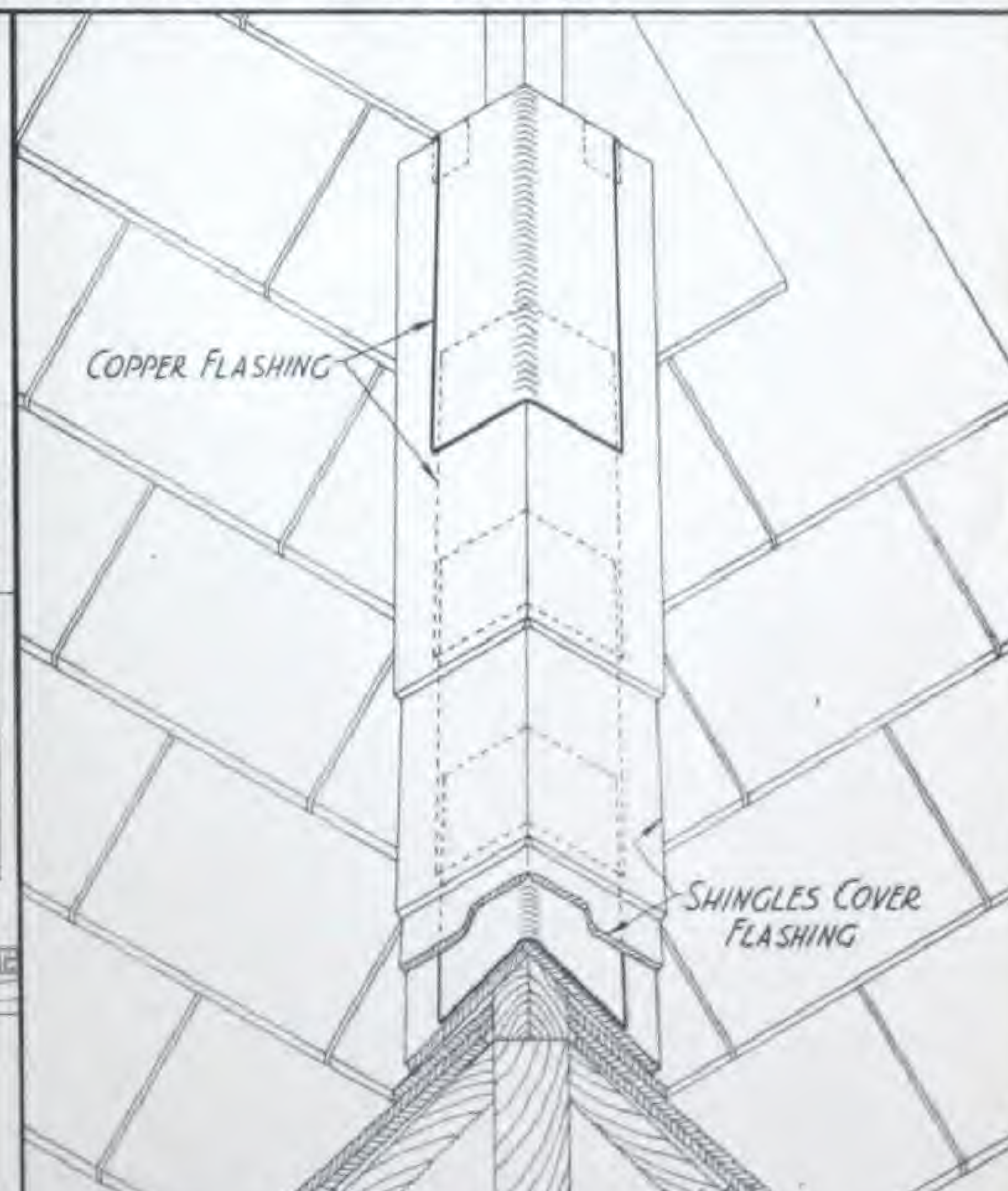
Where the length involved for ridges and hips is fairly short, say 30 feet or under, the type of connecting joint between sheets forming them is immaterial so long as it is watertight. According to conditions of slope and drainage, it can be either lapped, locked or soldered. Where the dimensions involved are greater than 30 feet, continuous runs should be broken up by some type of loose-locked joint or a type of construction which will permit proper movement of the metal.



HIP OR RIDGE FLASHINGS FIG. 53



HIP FLASHING FIG. 54



SADDLE HIP FLASHING FIG. 55

RIDGES AND HIPS (CONT'D)

Fig. 56 presents two ways of flashing a tile roof surmounted by a flat deck covered by copper roofing. The method on the left is used when the tile finishes below the copper roof level and the roofing laps over the edge of the tile. A tile deck mould is secured to the roof sheathing by copper or copper alloy nails just above a special piece called a "top-fixture." The flashing is turned down over the deck mould far enough to lap 4", the lower edge being hooked over a cleat or edge strip for fastening. The upper or roof edge of the flashing is formed into a soldered flat seam securely held to the roof sheathing by copper cleats.

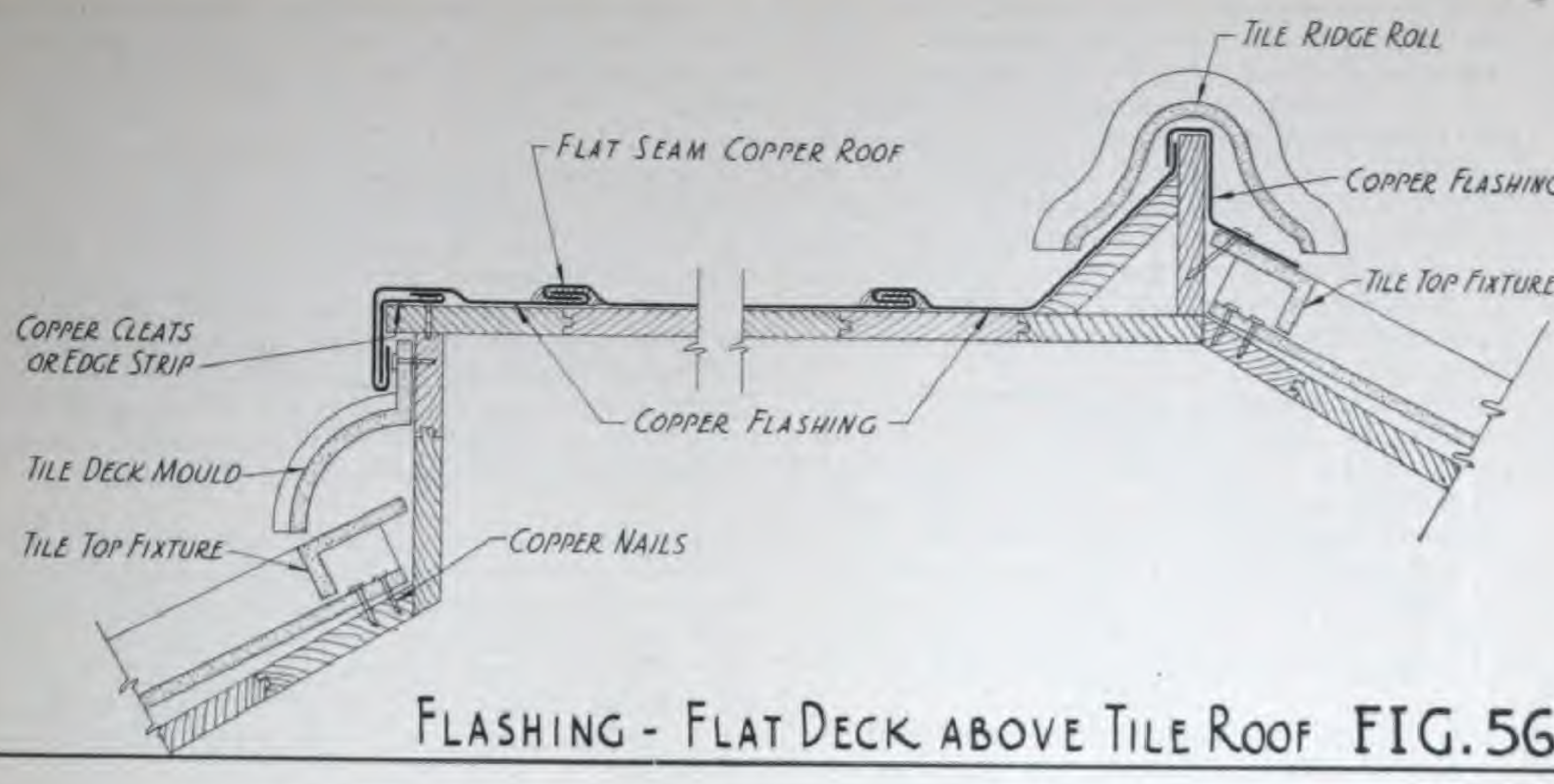
The method indicated on the right shows the flashing when the tile ends above the roof instead of below. The flashing is carried up at an angle on a cant strip to the top of a ridge board, where it is lapped by another piece carried out on the tile top fixture about 4". The ridge roll then is placed over the copper flashing, the weight of the roll holding it in place. This flashing also is secured to the copper roofing of the main deck roof by soldered lock seams.

In laying both types sharp angles should be avoided. Horizontally the ends of the sheets should be joined by a soldered lap or lock seam.

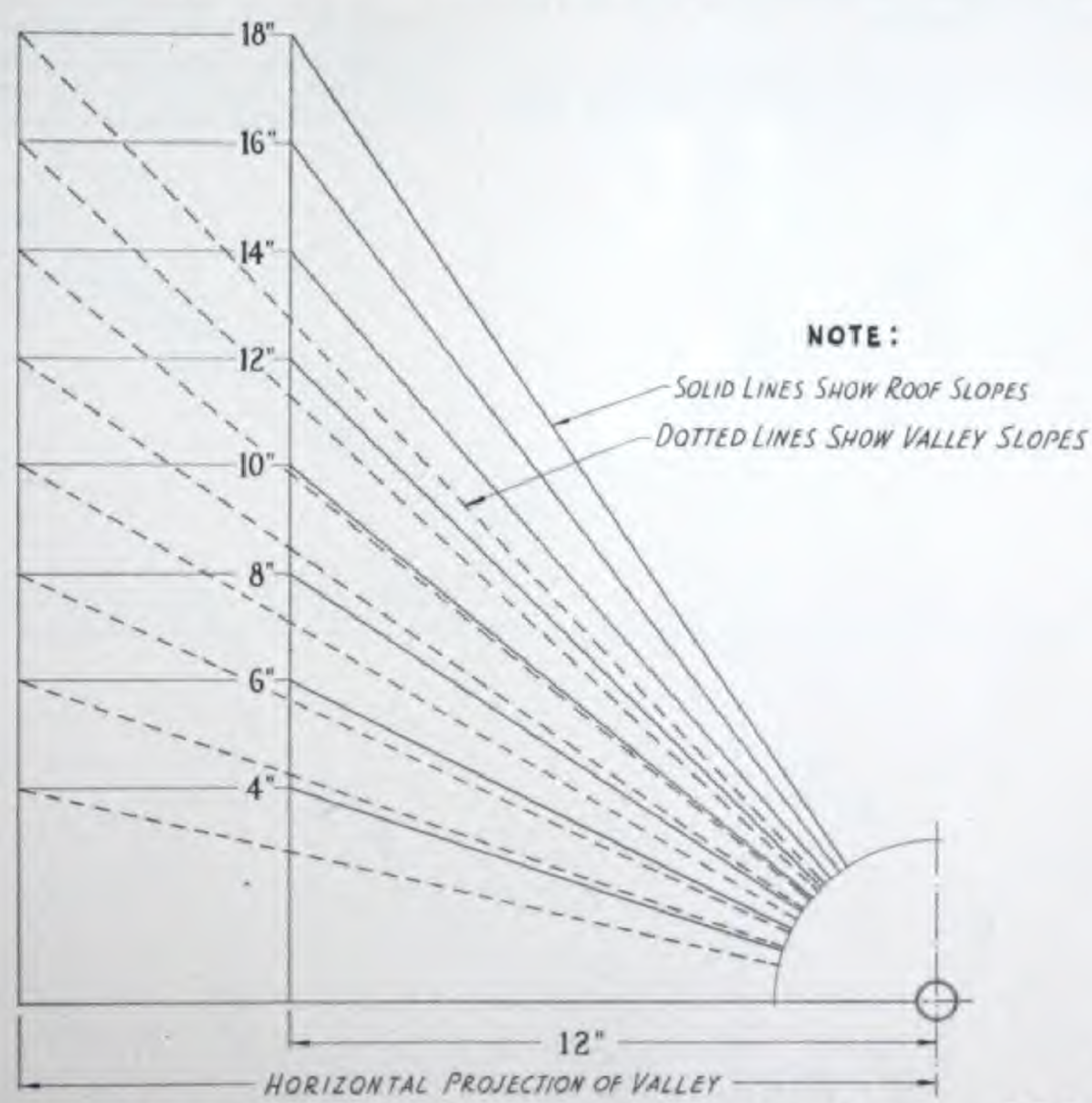
VALLEYS—OPEN AND CLOSED

Where two descending roof areas intersect, a valley is formed, and there are two general methods of providing the flashing, viz., "open" valleys, and "closed" or concealed valleys. The closed valley usually is confined to the intersection of slopes having the same pitch and about equal areas. Varieties of open valley construction can be used for all cases. Knowing the pitch of a valley is important in carrying out its design and construction.

Fig. 57 shows valley pitches for corresponding roof pitches, where the valleys are formed by two roofs having the same pitch. The solid lines represent various roof pitches in inches rise per foot of horizontal projection, and the dotted lines give the corresponding valley pitches which are flatter because the valley slope has a greater horizontal projection than the roof slope for the same vertical rise. A more complicated diagram can be worked out to show the slope of a valley formed by two roofs with unequal pitches, but is not shown here because of the many possible combinations.



FLASHING - FLAT DECK ABOVE TILE ROOF FIG. 56



GRAPHICAL DIAGRAM OF ROOF AND VALLEY SLOPES FIG. 57

Open Valleys

Fig. 58 shows an open valley flashing where the two intersecting roofs have the same slope. The valley sheet should be of 16-oz. soft (R. T.) copper, either rolled sheet or of sufficient full length (96″) sheets. The cross seams usually are locked and soldered. A better installation where separate sheets are used, is to lap the sheets at the cross seams, and leave them unsoldered. This cares admirably for expansion and contraction, and is strongly recommended. In such construction the sheets should have a head lap (vertical distance between bottom edge of upper sheet and top edge of lower) of at least 2″.

Side edges of the flashing are folded back onto the sheets to form ½″ locks for cleating. The valley is secured with 2″ soft copper cleats 12″ on centers and each fastened with two copper or copper alloy nails. Cleat ends should be folded to cover nail heads.

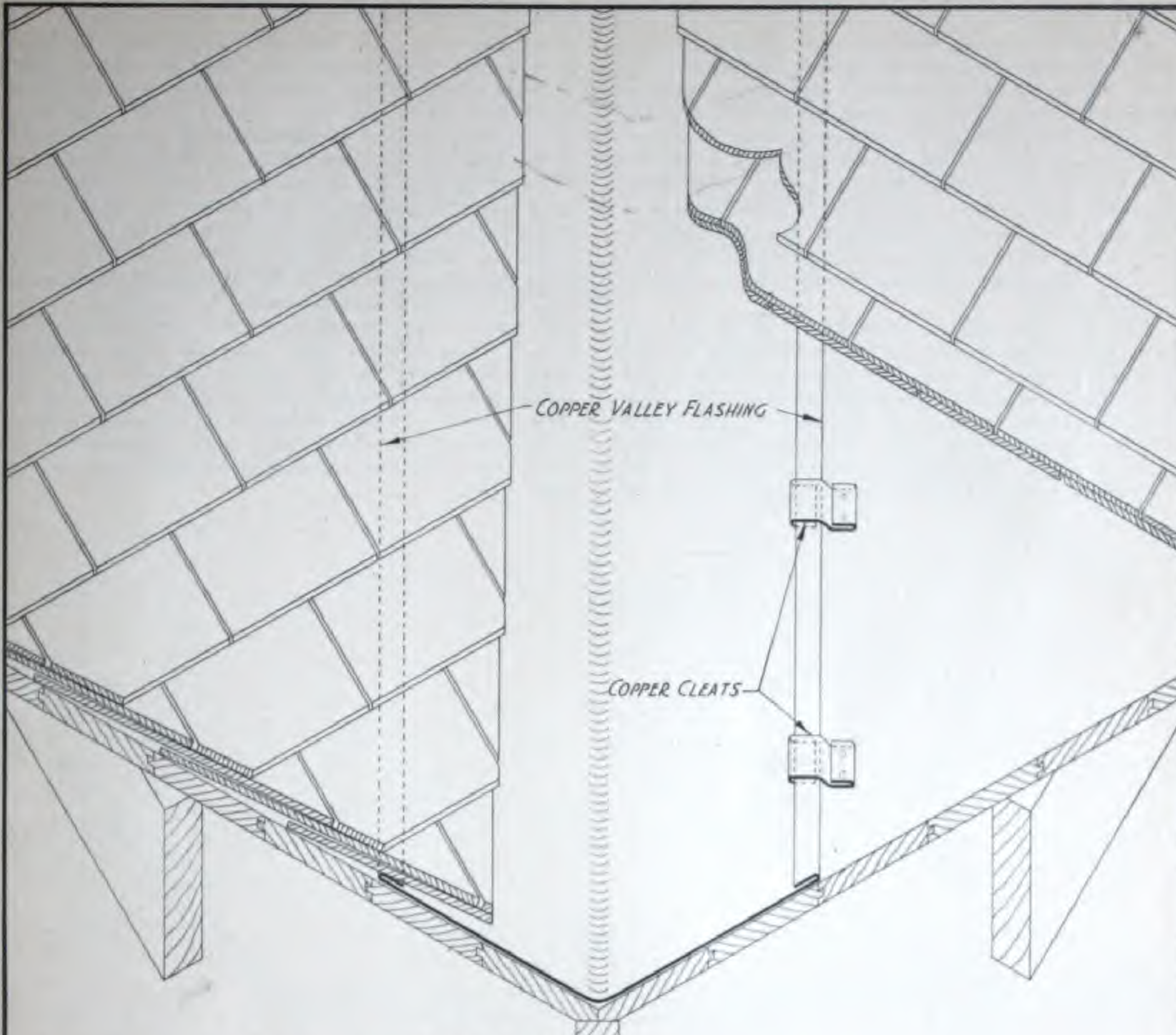
Slates or shingles should be laid so the exposed portion of the valley is not less than 4″ wide at top, increasing in width 1″ in 8′ toward the gutter. This taper facilitates drainage and minimizes trouble from ice and snow.

In width the flashing should cover the open portion of the valley and extend under the roof covering not less than 4″. The metal should not be pierced by nails fastening slates or shingles.

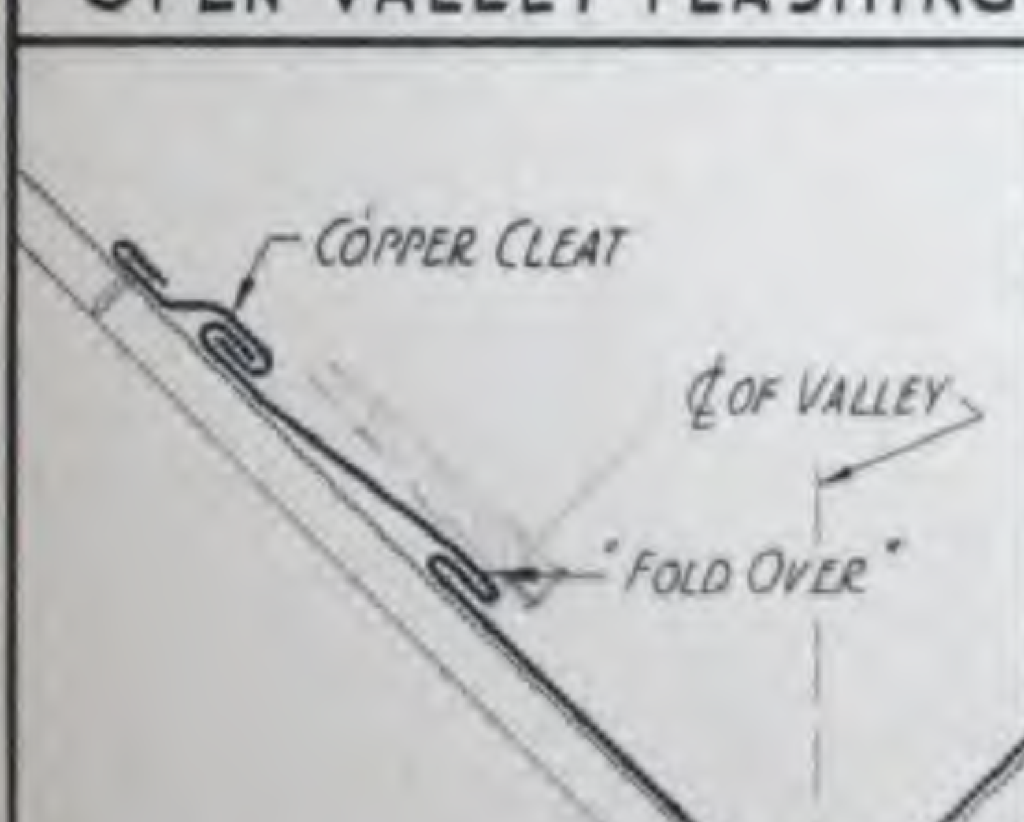
Fig. 59 illustrates another method of constructing an open valley, embodying the fold-over feature. The advantage here is that the crimp raises the butts of the slates or shingles away from the metal, thereby reducing the possibility of "line corrosion." This "line corrosion" where shingle, metal and air come together, sometimes occurs in localities where the contents of the atmosphere make corrosive solutions from moisture held by capillary attraction at the metal-shingle-air line. To raise the shingle butts prevents moisture being held in contact with the metal. In the drawing a slight opening has been left between the layers of metal to illustrate the method employed. In practice the metal should be pressed together in both these places, insuring an even ridge for the shingles to rest upon. The additional thicknesses of metal are sufficient to raise the shingles the required amount.

Fig. 60. When two adjoining slopes of a roof deliver unequal quantities of water to a valley, the larger quantity of water may force the smaller quantity back on itself and up beyond the top of the flashing. To prevent this a 1″ crimp sometimes is put in the copper at the bottom of the valley, as shown. This breaks the force of water and prevents it from ascending the opposite slope.

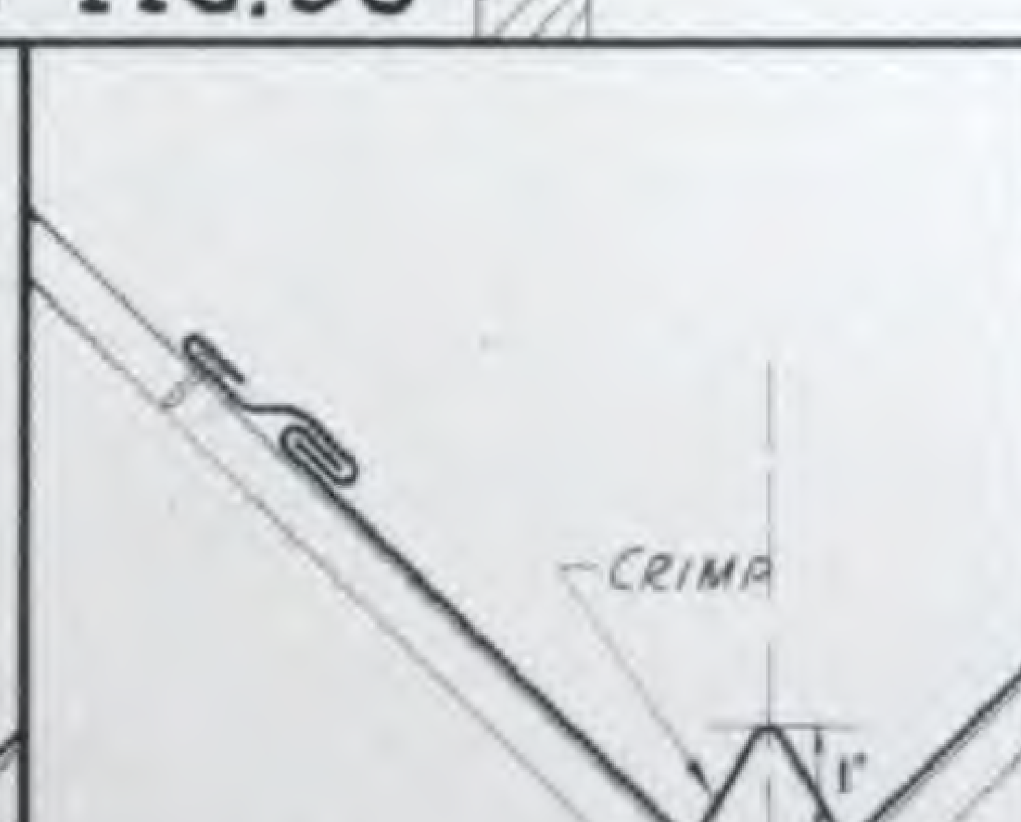
Fig. 61, instead of the crimp pictured in Fig. 60, shows an angle, or tee, formed of copper. It is soldered to the valley sheet on the slope opposite the one which delivers the larger quantity of water.



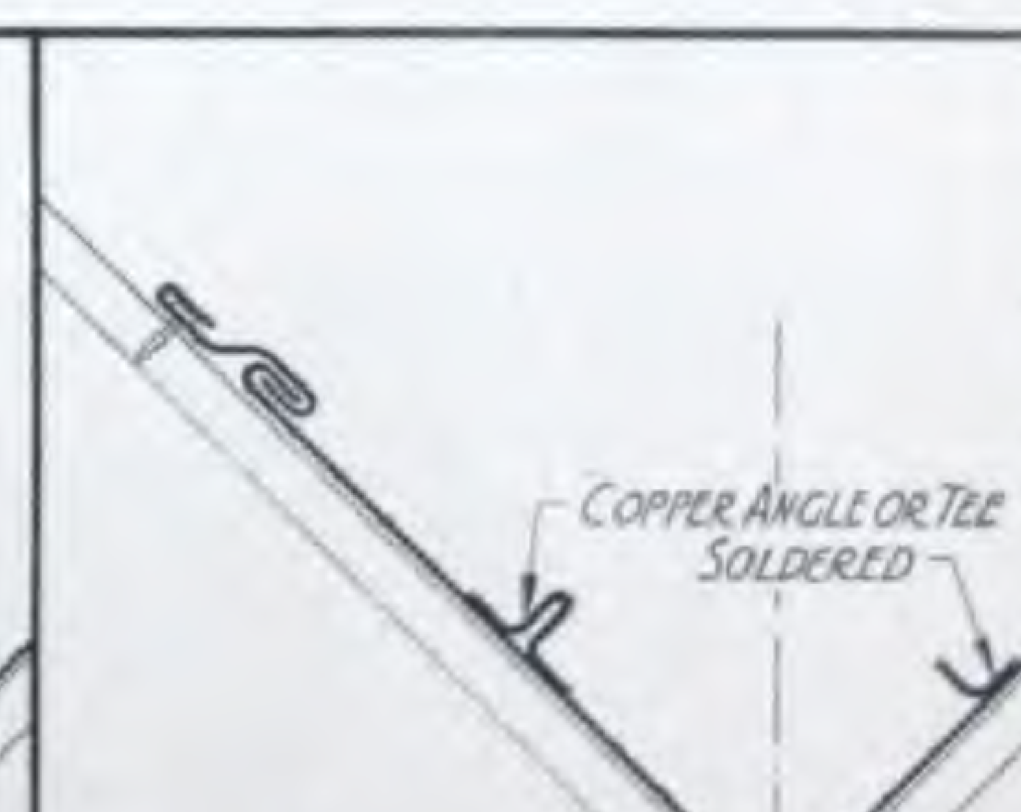
OPEN VALLEY FLASHING FIG. 58



"FOLD OVER" VALLEY FLASHING FIG. 59



"CRIMP" IN VALLEY FLASHING FIG. 60

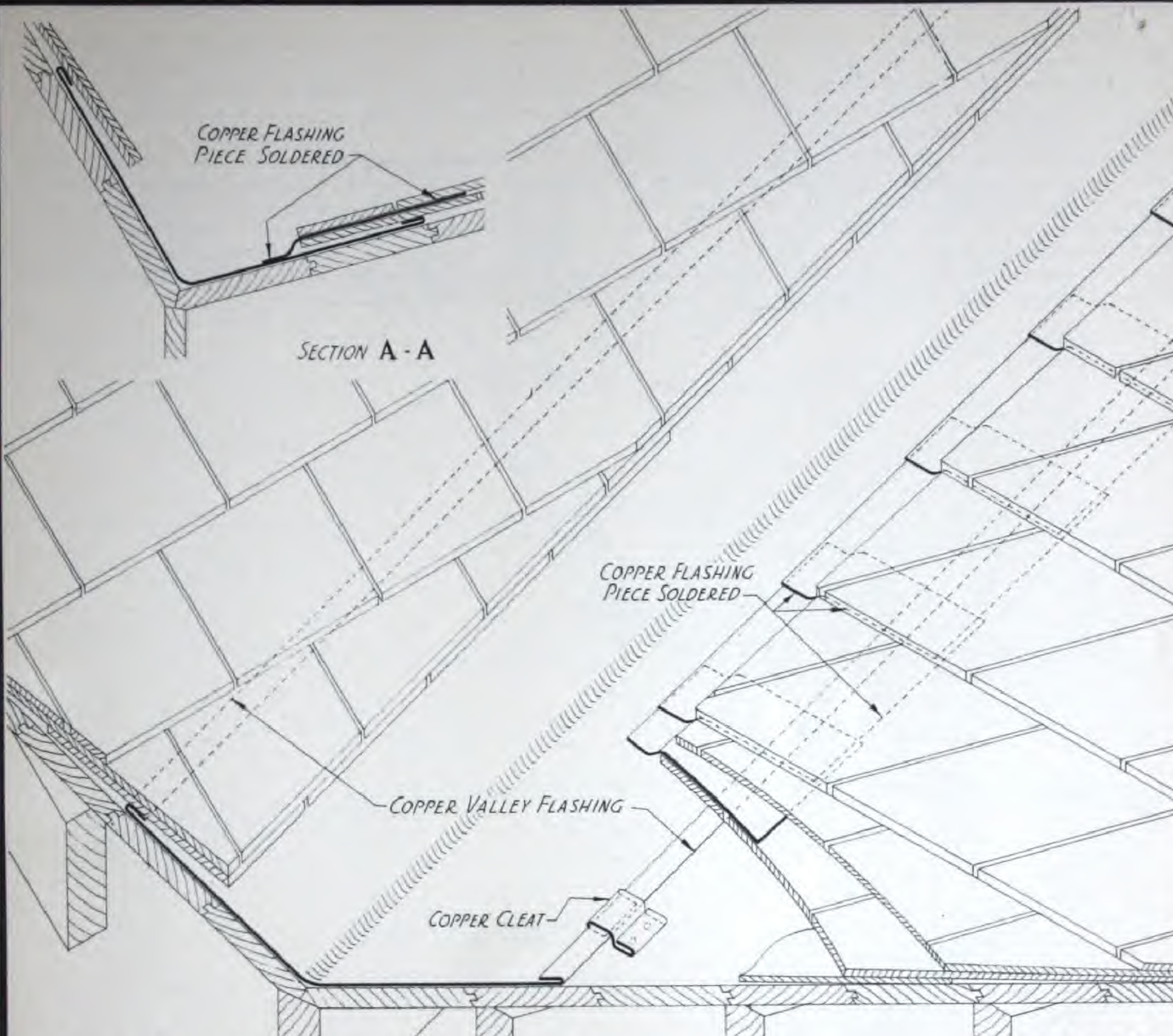


"ANGLE" IN VALLEY FLASHING FIG. 61

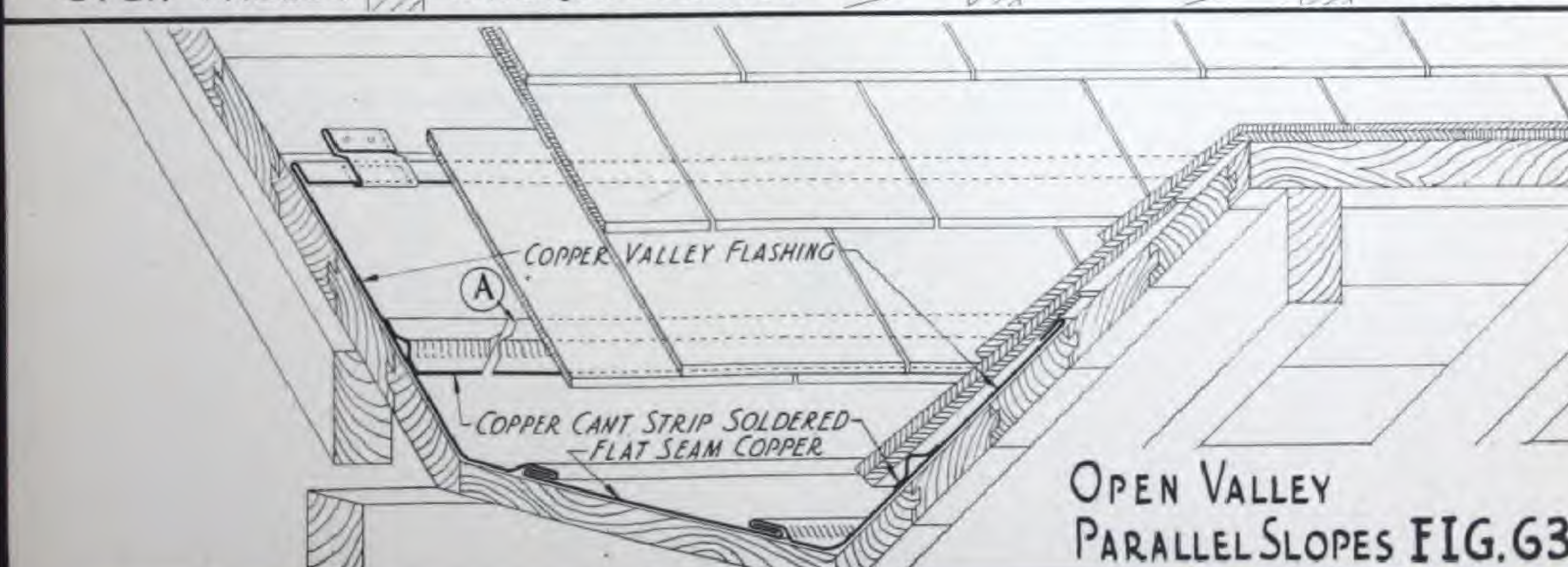
Open Valleys (cont'd)

Fig. 62 shows recommended construction in extreme cases, where one of the roof slopes running into the valley is almost flat. Copper flashing pieces are inserted between each pair of shingles next to the valley on the flat slope. Each flashing should lap the next lower one 3". The pieces are cut and formed to fit as shown in the section view, and are soldered to the main valley flashing. This construction, obviously, is more expensive than the two previously illustrated, but gives greater safety where one slope is so much steeper than the other that in a downpour water would wash over a crimp or soldered cut-off.

Fig. 63. If a valley is formed by two parallel roof slopes, that is, when the ridges of the roofs are parallel so that the shingles meet the valley practically perpendicularly from both sides, the slope of the valley (actually a gutter) is very flat, and special construction should be employed to raise the shingle butts away from the metal. The fold-over flashing, Fig. 59, is not as satisfactory for very flat slopes as the use of a metal or wooden cant strip fastened to the valley flashing. If a wooden strip is used, it is held by copper cleats 2" wide folded over the batten as straps, their ends being soldered to the valley. (See Fig. 93.) The strip of crimped metal, as illustrated in Fig. 63, is soldered to the flashing. The cant strip should be placed from 1" to 2" back of the shingle butts, and ¼" openings, as at point "A", should be left in the strip at intervals to allow drainage for possible moisture. The cant strips should be sufficiently high to permit proper laying of the slates. This will also insure against moisture being held at the metal-shingle-air line by capillary attraction, which is apt to cause chemical corrosion in acid-forming atmospheres. (See page 46.) The flashing should be carried up the sides to extend under the second course of shingles, and should be fastened with cleats. In the example shown, a wide trough is provided calling for soldered flat seam construction to avoid expansion and contraction troubles in the use of large sheets.



OPEN VALLEY — UNEQUAL SLOPES FIG. 62



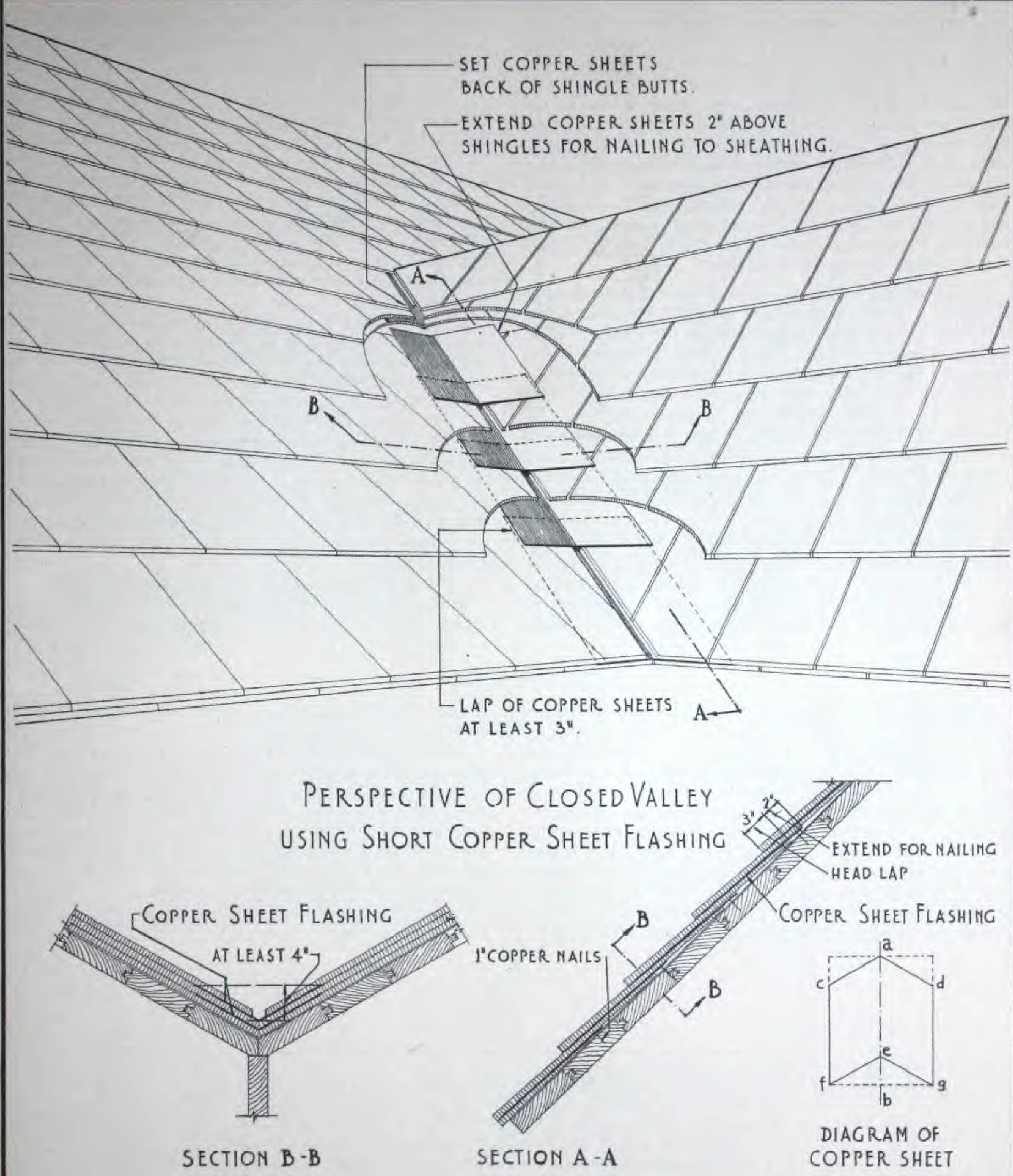
OPEN VALLEY
PARALLEL SLOPES FIG. 63

Closed Valleys

Fig. 64. Closed valleys are used, where slopes are sufficient, when it is architecturally desirable to have the flashing metal concealed. They are recommended only for steep slopes, 45° pitch or more.

This construction calls for a series of separate copper sheets inserted between every course of shingles. The sheets may be made from large sheets or rolls, as is shown in the diagram at lower right by cutting along the parallel lines *ac* and *ef*, and *ad* and *eg*. The cut sheets are folded along the line *ae* to fit the valley. This is all done in the shop, and all sheets for the same valley are made alike from a templet. An accurate templet should be made, preferably on the job, as the dimensions of the sheets and the angles at which they are cut and folded depend on the roof slopes. Rectangular sheets also may be used, but they employ more metal.

The flashing sheets should lap the shingles below at least 3″, and should be carried down just short of the butts of the course above. For nailing, the sheets should be long enough to carry 2″ above the slates or shingles immediately under them. They should be sufficiently wide to give a vertical lap of at least 4″ as shown in Section B-B.



CLOSED VALLEY FLASHING FIG. 64

CHANGES OF SLOPE

Fig. 65 shows method of flashing at the change of slope in shingle or slate roofs. The copper should extend under the shingles of the upper slope as far as possible without being punctured by nailing, and cleated. On the lower slope the flashing extends out 3″ or 4″ on top of the shingles to cover the nail holes. A cant strip is shown to raise the butts of the last course on the upper slope to permit proper laying of the shingles. The strip should be placed over the flashing and held with soldered straps as in Fig. 93. The exposed end of the flashing is screwed down with copper alloy screws through washers, if extended down so far that its own rigidity is not enough to keep the sheet tight.

Fig. 66. If a closed and mitred joint is desired with shingles, a concealed flashing is used. On the upper slope the copper sheet lies under the last course and is held with cleats. On the lower slope it is carried down between the shingles of the top double course to within ½″ of the butt of the top shingle. This course of shingles is fastened with countersunk copper alloy screws passing through lead washers inserted immediately on top of the flashing between the two courses. The washers prevent leakage through the holes in the shingles or slates. A cant strip is provided on the upper slope as in Fig. 65.

Fig. 67 shows method of flashing a flat copper deck built over a sloping shingle roof. The flashing should lap the shingles 4″ and be joined to the copper roofing by a soldered flat-lock seam turned in the direction of the flow. If there is danger of the lower portion being lifted by wind it should be held with cleats, as in Fig. 73 or by copper alloy screws through lead washers with screw heads soldered.

Fig. 68 shows flashing for a flat deck covered with felt-and-gravel roofing above a sloping shingle roof. The lower edge of the copper is turned back on itself ½″ for stiffness, and should lap the shingles at least 4″. It is brought up on to the main roof and, after forming a crimp (or soldering on a separate crimp as shown in Fig. 110) to retain the gravel, is extended out on the roofing 4″ to 6″ and nailed at about 8″ intervals near the inside edge, through the felt into the sheathing. The joint between metal and felt is made tight as described below.

If the vertical distance from shingles to top of crimp is more than 8″ it may be advisable to make the flashing in two pieces joined by a flat-lock seam secured by cleats to the vertical surface of the roof boards. Such a seam would be unsoldered and filled with white lead.

The copper should extend out on the roof on top of the felt 4″ and be nailed through the felt to the sheathing with copper or copper alloy nails and then covered with two additional layers of felt extending 6″ out on the roof. The metal also may be laid between the layers of felt instead of on top, but most roofers prefer the former method, as it prevents interruption of the roofing work.

The copper never should be laid directly on the roof boards. The felt will pull away from the copper causing an open joint at the junction of copper and felt.

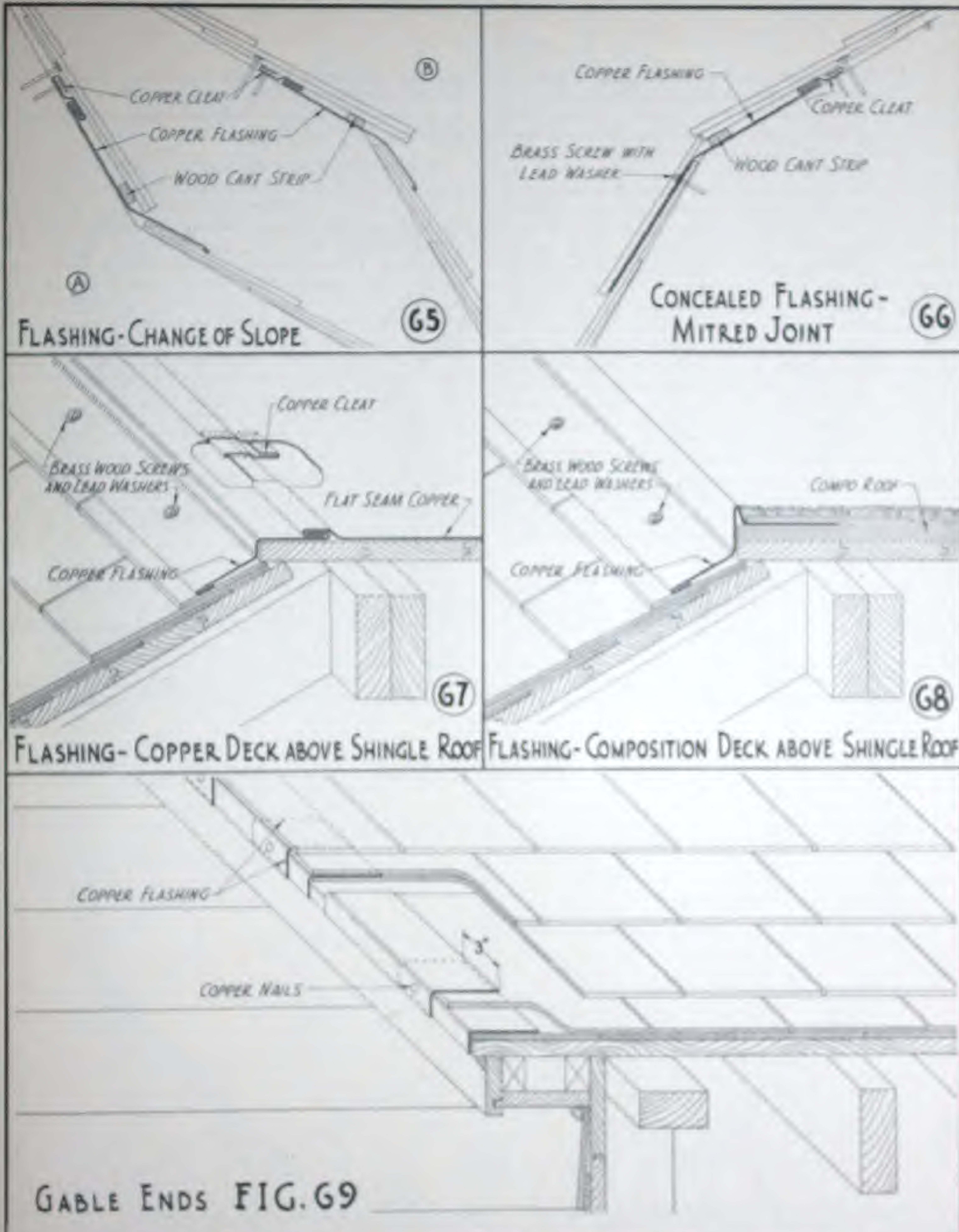
GABLE ENDS

The methods of finishing the gable ends of copper roofs are described under the respective types of roofing. Slate and shingle roofs very frequently are left unflashed at the gables. Copper flashings sometimes are desirable, however, and they are placed at each course as shown in **Fig. 69.** The flashings should lap each other at least 3″, and since the pieces are short they can be fastened with copper nails. The top edges are folded at right angles to slip under the shingles as shown. Such flashings dress the roof edge and give it a more massive appearance. They prevent water being blown under the shingles, and edge-lifting and straining by winds. Highly important, too, is the cutting off of air currents and heat losses.

Roof edging is also important on built-up and composition roofs which are not enclosed by parapets or walls. Copper flashings along such exposed edges make the roofing watertight and prevent the layers from being separated and lifted by wind. Some distributors stock special strips for this purpose in 10′ lengths. They are generally in the form of angles, with or without a projecting fold to act as a drip at the corner.

Another type of edge finish is the gravel stop illustrated in Fig. 126.

NOTE: The Figures on the following ten pages do not indicate clearly the provisions for longitudinal connections between flashing sheets. Use of sheets with a maximum length of 8 feet is recommended. When the total length of the run is under 30 feet, adjacent sheets can be lapped 4″ to 6″, or locked. Joints may be left open, or filled with white lead, or soldered, as local conditions may indicate. Where longitudinal dimensions exceed 30 feet, the runs should be broken up by some type of joint which permits movement, so that no soldered construction exceeds that dimension in a single run. (See also page 13.)



FLASHING-CHANGE OF SLOPE 65

CONCEALED FLASHING-MITRED JOINT 66

FLASHING-COPPER DECK ABOVE SHINGLE ROOF 67

FLASHING-COMPOSITION DECK ABOVE SHINGLE ROOF 68

GABLE ENDS FIG. 69

WALL FINISHES

Shingle Roofs

Fig. 70 presents a method of flashing between a shingle or slate roof and a vertical wall when the wall runs along the side of the roof. This is an application of the familiar cap and base flashing. The base flashings are woven into the shingle courses, and are hooked over the tops of the shingles, as shown at top of the drawing. The cap flashings are inserted between the brick courses, and should lap over the base flashings at least 4". The cap flashings lap each other at least 3" at the sides, and the base flashings, being carried down nearly to the butts of the shingles immediately above them, lap each other about 3". Cap flashings are best built into the wall as the masonry is erected. If this cannot be done, the joints must be dug out at least 2" deep, and the flashing secured with lead plugs as described on page 36. To facilitate later inserting the flashing, easily-removable wooden strips or sand courses, can be introduced in the joints where the flashings are to come. Note the foldbacks at the bottom edges of the cap flashings for stiffness.

In extreme exposures and where warranted by the class of work, the exposed edges of the cap flashings can be carried into the vertical joints of the brickwork above the next step flashing and the caps soldered where they lap at the sides. This prevents water being driven in under the vertical edges.

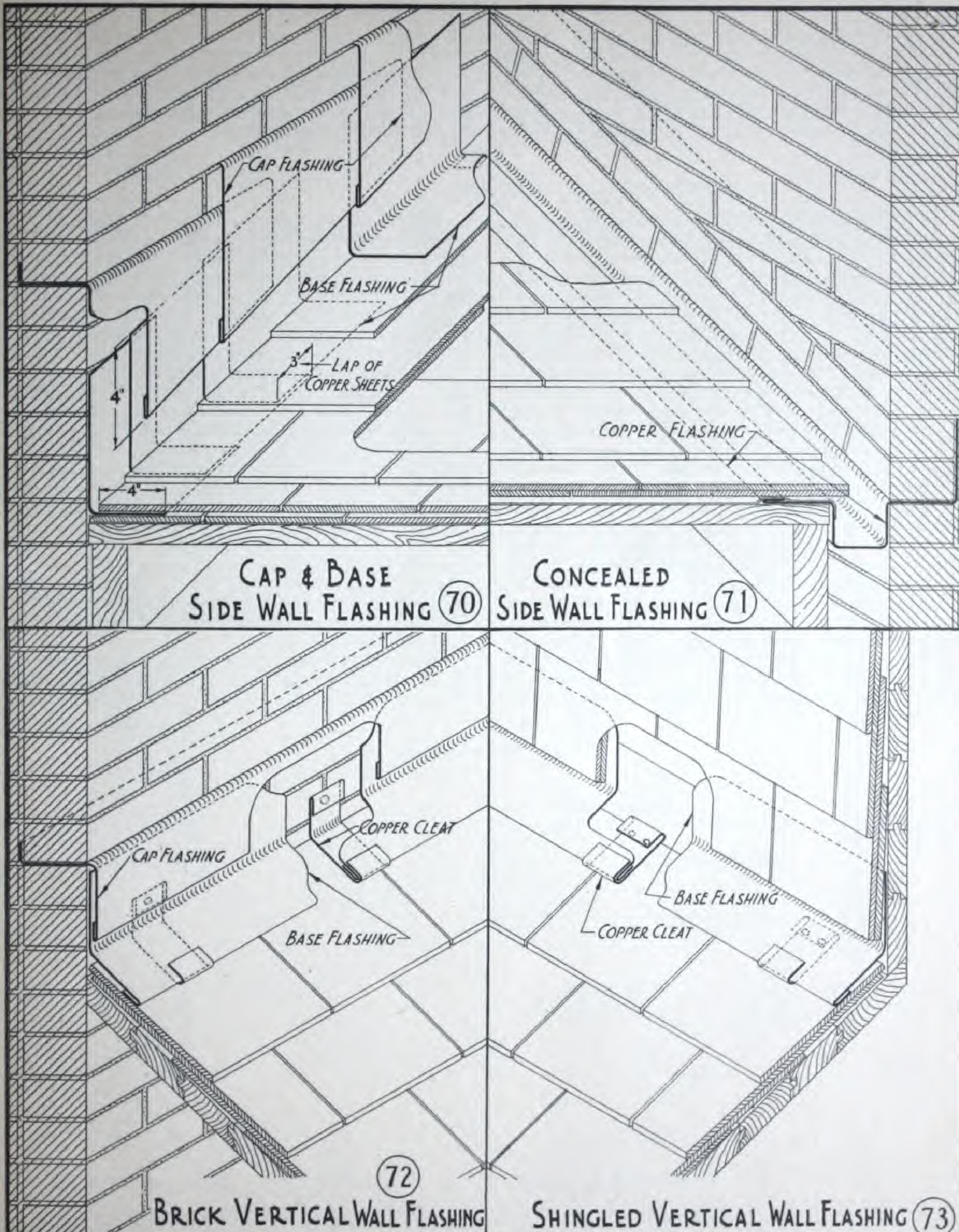
Fig. 71 shows installation of a concealed flashing. The width of the portion forming the concealed gutter should be not less than 3". The flashing is inserted in the masonry the width of one brick, and extended up back of two bricks. The bricks are laid parallel to and flush with the roof line, being cut to conform to the slope where necessary to receive the continuous flashing. On the roofing side the flashing is carried in 4" immediately on top of the sheathing and under the felt as shown. The shingles will overhang the concealed gutter slightly.

Fig. 72 shows the method of application when a shingle roof abuts a brick wall at the top of the roof. Each end of the cap flashing is turned back as shown, the built-in end to act as a dam, the lower for stiffness. The flashing is built into the brickwork as the wall progresses. The cap flashing should lap the base flashing 4". The base flashing should extend out on the shingles 3" or 4" to cover the nails, and before being placed the lower edge should be turned back on itself $\frac{1}{2}$" for stiffness. The base flashing is held by cleats 12" apart secured to the brickwork by copper or copper alloy nails driven into the joints. To complete the job the cap flashing then is turned down over the base flashing in the usual way. The sheets forming both base flashing and cap flashing should lap horizontally at least 3" if the lap is not to be soldered, and $\frac{1}{2}$" if soldered. Soldering should be used only on short runs.

If the roof pitch is sufficiently steep that the flashing need be carried up the masonry but 2", the flashing can be made in one piece.

Fig. 73 shows method of flashing when a shingle roof abuts a shingled wall. The flashing should be carried up on the wall sheathing at least 4" under the shingles and secured along the upper edge by copper or copper alloy nails. On the roof the flashing extends about 4", and if required can be held down with cleats, or screws with heads soldered, spaced 12" to 18" on centers. Note the $\frac{1}{2}$" fold-back of the lower edge.

See also Note on page 52



CAP & BASE SIDE WALL FLASHING (70)

CONCEALED SIDE WALL FLASHING (71)

(72) BRICK VERTICAL WALL FLASHING

SHINGLED VERTICAL WALL FLASHING (73)

WALL FINISHES (CONT'D)

Fig. 74 shows method of flashing when the wall at the top is of rubble stone. The wall is started in brick to form a level base for the flashing. After the flashing is placed, the stone is started on a thick bed of mortar. The flashing continues down over the roofing as in Fig. 73, and if necessary may be held against wind lifting as there described. The flashing is shown carried completely through the wall—a "through flashing," construction which always should be employed in the walls of tall buildings which are subject to moisture penetration when rainstorms are accompanied by driving winds of high velocity.

Tile Roofs

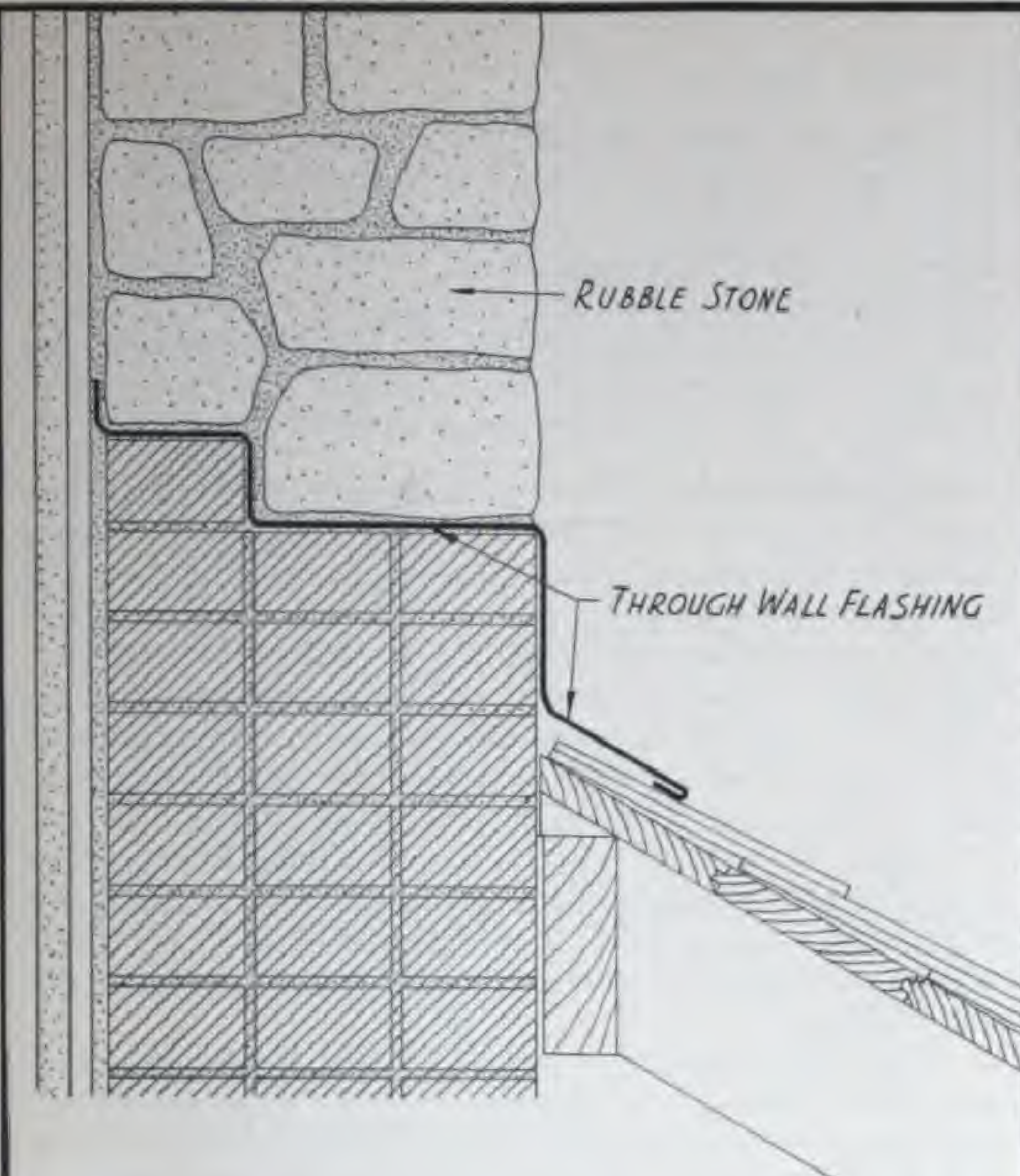
Fig. 75 pictures the method of flashing when a tile roof meets a brick wall at the sides of the roof. The base flashing should extend out on the roof just far enough to avoid puncture by the nails used in securing the tile, and then be turned up at right angles to the roof as high as the edge of the tile and cleated. The flashing should be carried high enough on the brick so the cap flashing, when in place, will lap the base flashing at least 4". The cap flashing should be laid in the brick joints as the wall is built and stepped as required by the slope of the roof. Before being placed in position each end of the cap flashing should be folded back ½" as shown. Each sheet of the cap flashing should lap outside the next lower sheet at least 3", but if the lap is to be soldered this may be reduced to ½".

Fig. 76 shows flashing when a tile roof abuts a brick wall at the top of the roof. The construction is similar to that for a shingle roof shown in Fig. 72. The cap flashing should lap the base flashing 4", and both cap and base flashings should lap horizontally at least 3" if left unsoldered. The base flashing extends out on the roof tile as far as the edge of the tile "top-fixture," and may be held down by copper cleats previously nailed in the brickwork about 12" apart to meet the joints. (See Fig. 72.) Sometimes cleats are tucked under the tile top-fixture and soldered to the flashing.

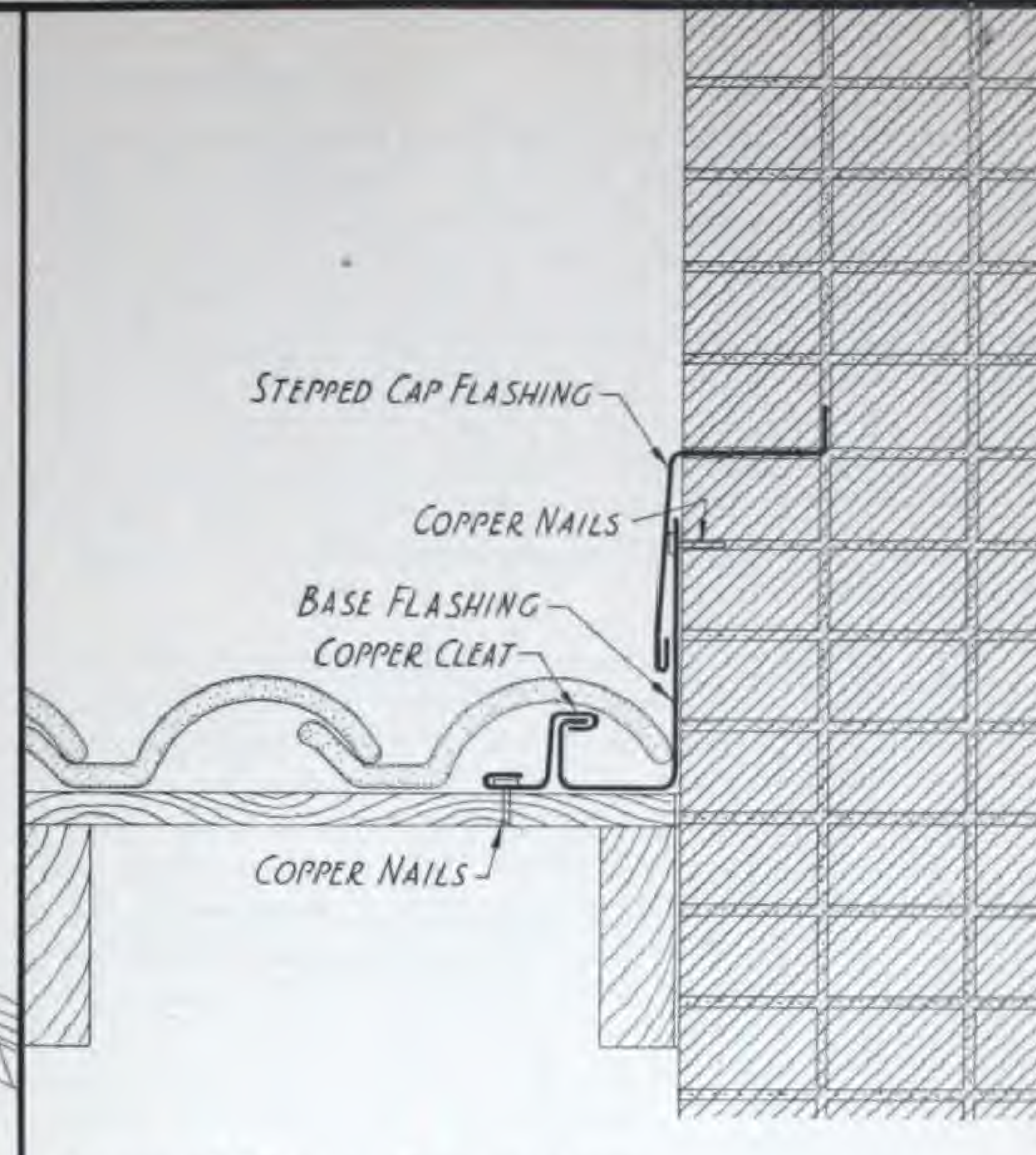
Fig. 77 shows a dormer window or other vertical structure on a tile roof and the method of flashing. The upper part of the drawing shows the flashing against the side wall, and the lower part the flashing against the front wall. In side wall construction the flashing is carried out on the roof and turned up against a wooden strip supporting the tile and also up on the vertical wall as far as necessary, but never less than 4", being nailed to the sheathing at 8" intervals. The tile is kept a short distance from the wall so the flashing forms a small gutter. Provision must be made at the low point for connecting this flashing with the main gutter by continuing it under the tile to the eaves, or else it must be run out on top of the tile. On the front wall the flashing is placed against the sheathing and carried up at least 4". When a window occurs in the wall the flashing should be carried well up under the window sill as explained in Fig. 124A. The upper edge of the flashing is nailed to the sheathing with copper or copper alloy nails about 8" apart. The lower edge extends out on the tile from 4" to 6", according to the slope of the roof and should be turned back on itself ½" for stiffness.

Attention is invited to the method of bedding the tile in cement mortar. This is necessary where the tile is cut or where water may drive under the flashing.

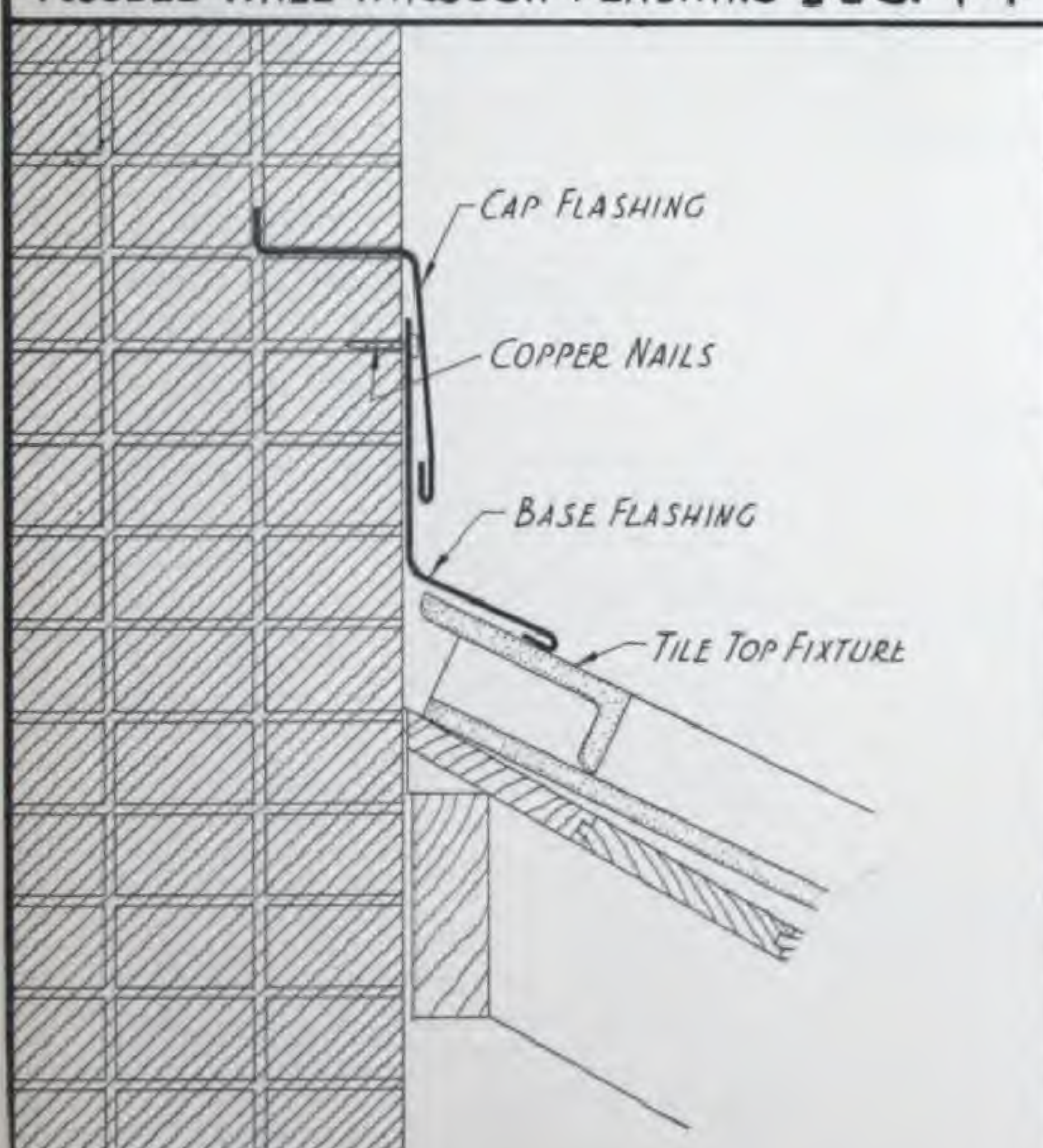
See also Note on page 52



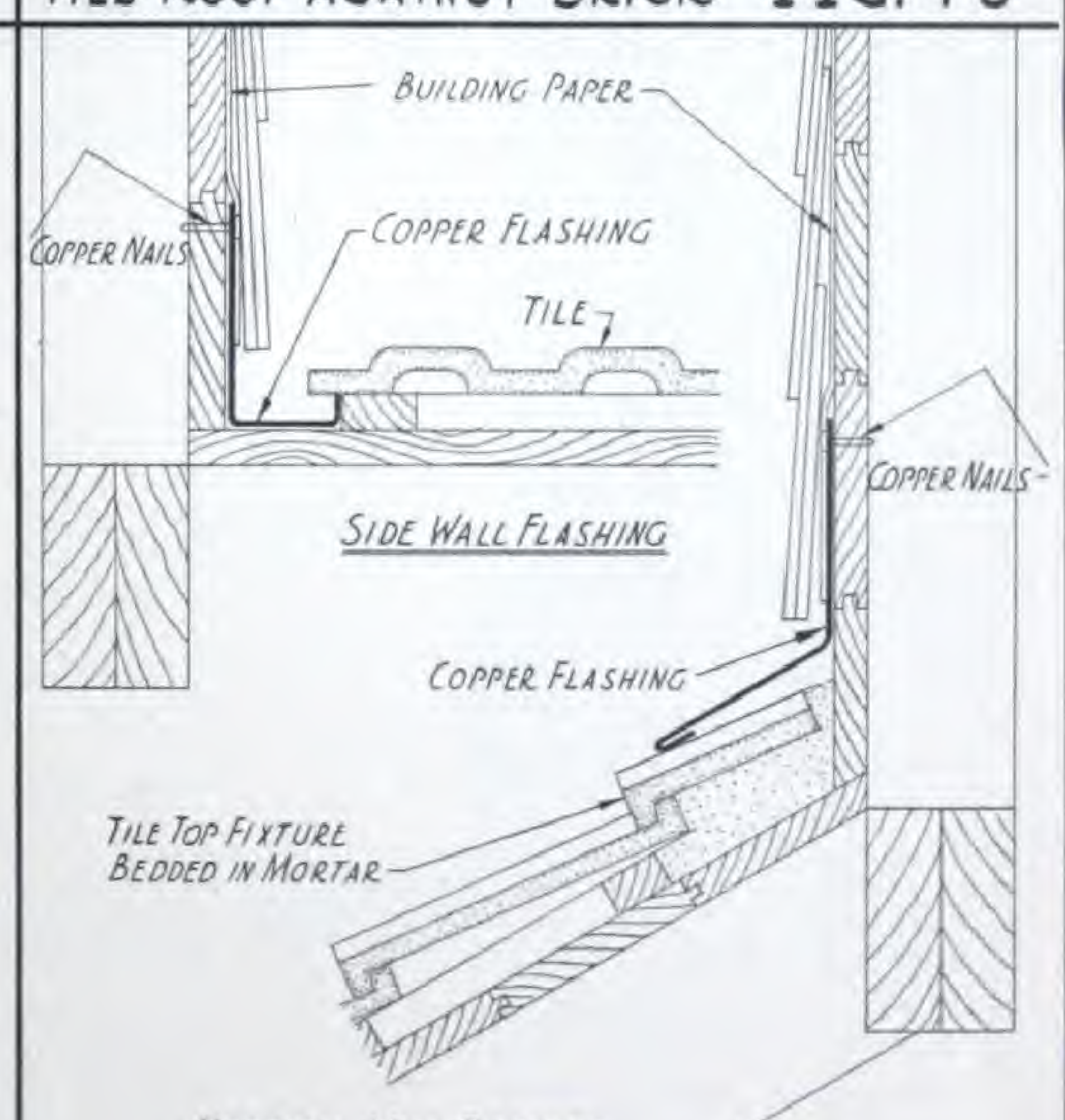
RUBBLE WALL THROUGH FLASHING FIG. 74



SIDE WALL FLASHING
TILE ROOF AGAINST BRICK FIG. 75



VERTICAL WALL FLASHING
TILE ROOF AGAINST BRICK FIG. 76



WALL FLASHING
TILE ROOF AGAINST FRAME FIG. 77

WALL FINISHES (CONT'D)

Composition, or Built-up Roofs

Special reinforcement of built-up roofing is required where it meets a base flashing. Three layers of felt saturated with pitch and extending 6″ up the walls and out over the roofing felt to lap 6″; 5″, and 4″ respectively, should be applied. The base flashing is then rounded (not sharply bent) into the proper shape and set in the angle against these layers of felt. The flashing strip extends out on the roof at least 6″ and up on the wall at least 6″. Over the metal strip on the roof two plies of felt at least 15″ wide are laid. These are cemented thoroughly to each other and the roofing by hot pitch.

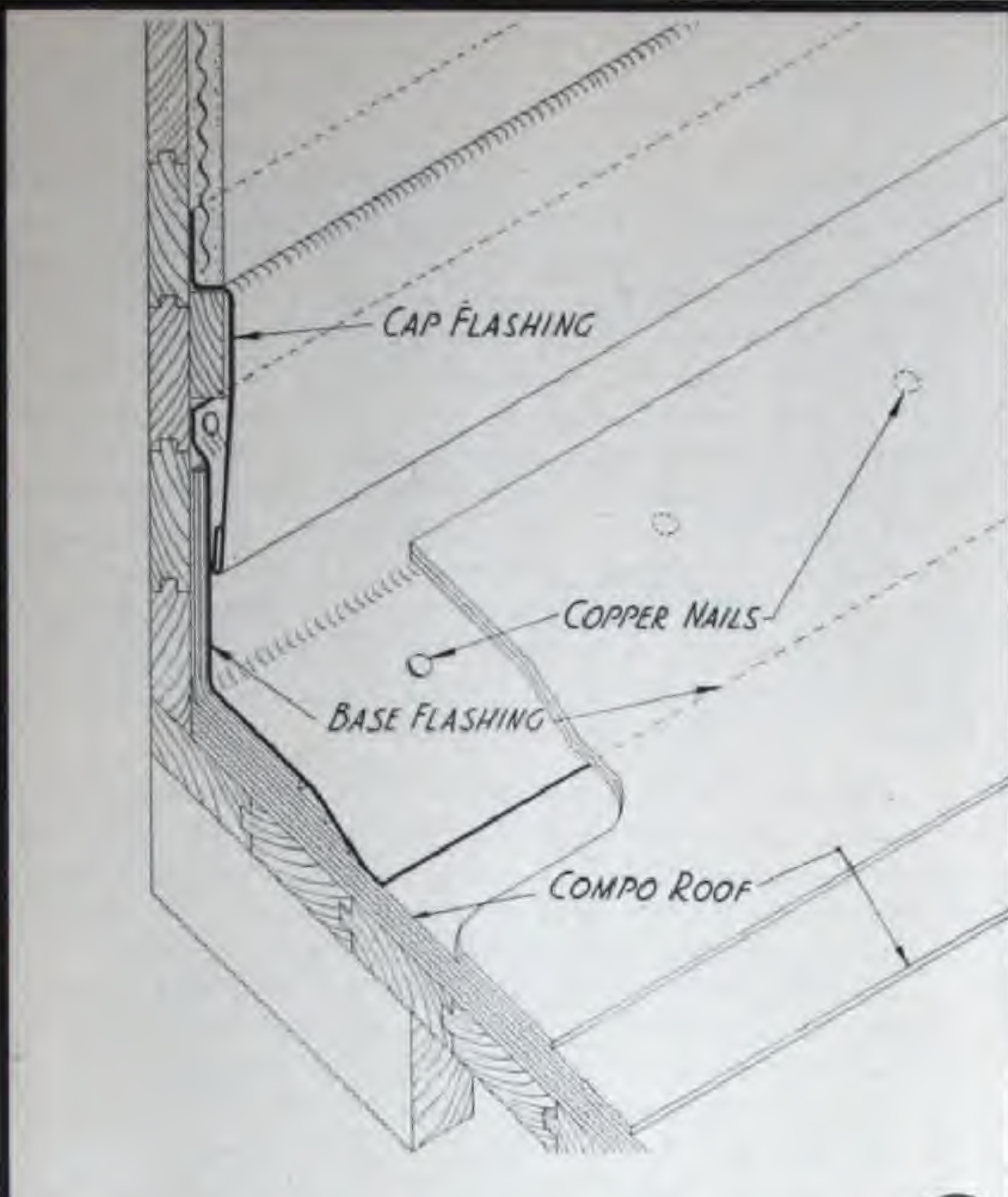
Fig. 78 shows method of flashing when a felt or other built-up roof abuts a wall covered with stucco. An extra board may be placed on the sheathing to bring the flashing out to the stucco face. The stucco lath should lap the cap flashing at least 2″. The base flashing should extend out on top of the roofing at least 6″ and be nailed to the roofing boards. If the roofing is laid on concrete, nailing concrete should be provided to take such fastening. If laid on gypsum, nails should penetrate 2″ or more. Two additional layers of the roofing material should be placed on top of the base flashing after the flashing has been swabbed with pitch. Base flashing should extend up far enough to allow a 4″ lap of the cap flashing. The lower edge of the cap flashing should be turned back on itself ½″. Joints in the base flashing are 1″ soldered lap seams, and the cap flashings are lapped 3″ and left unsoldered.

Fig. 79 shows method of flashing between a flat composition roof and a wall of stucco on a hollow tile base. The flashing is carried through the wall and keyed in the brickwork used to start the wall. The keying is better with this construction than if the flashing is worked through the block. The through flashing as shown is recommended when used at set backs in tall buildings. The base flashing is handled as in Fig. 78.

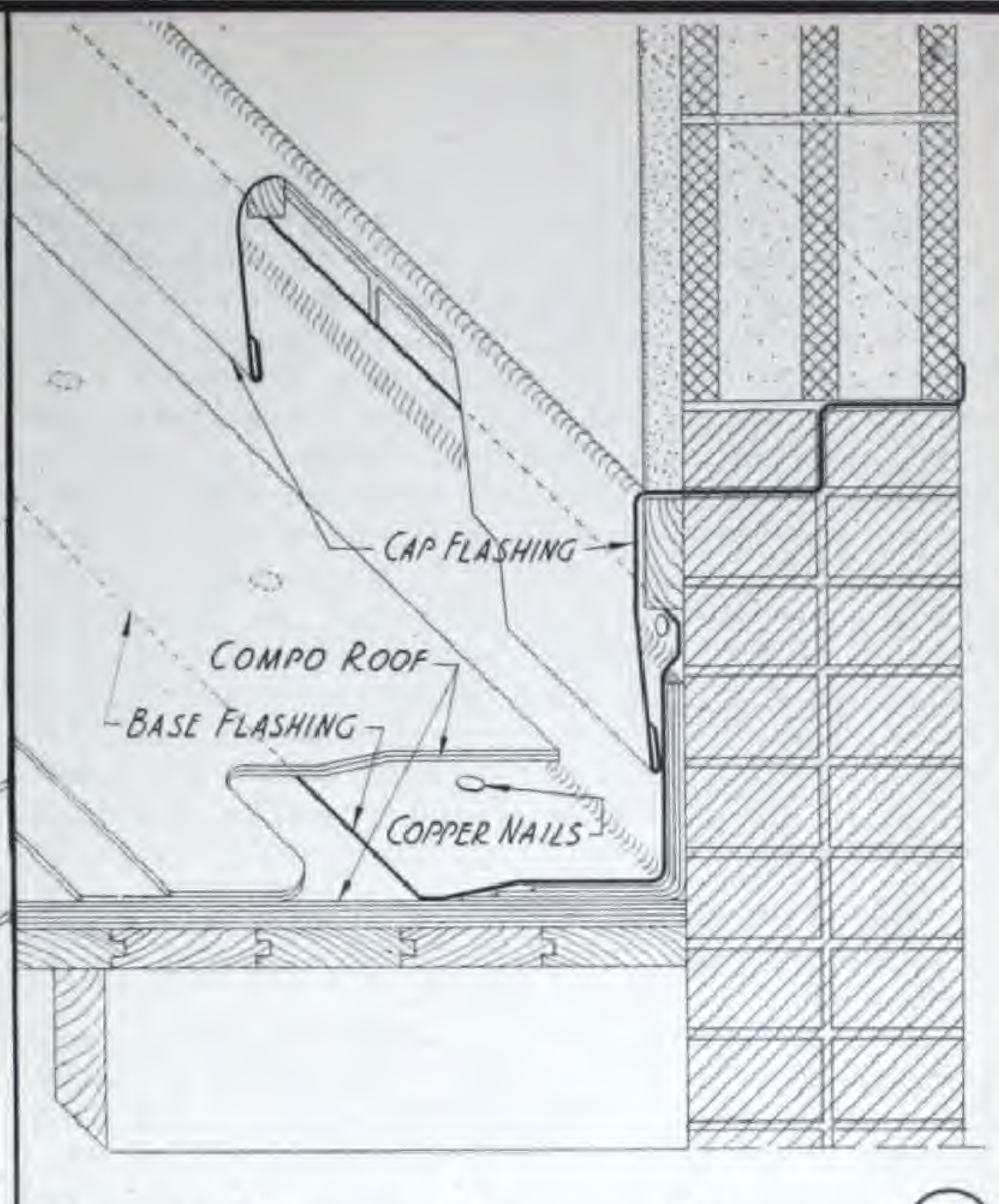
Fig. 80 shows method of flashing a set back in fireproof construction where the deck is covered with a composition roof. The junction of the roof surface and the upper wall must be flashed fully, not only against snow in northern climates, but because it virtually is impossible to build masonry walls impervious to driving rains. The cap flashing is stepped up in the masonry for keying, and carried through the wall to cut off water. The base flashing is placed as in Fig. 78, and is lapped at least 4″ by the cap flashing. For description of reglet construction see page 70. The cross seams of the outer cap should be soldered flat-locks, held with cleats. An alternate is a loose-lock seam instead of the cap and base.

The base flashing is held in place by copper nails spaced at intervals of about 8″. These nails are driven through the base flashing and the roofing felt, as shown in Fig. 78 and Fig. 79, but not in the sectional view of Fig. 80. The top edge of the base flashing is tacked occasionally into the sheathing or a mortar joint, as shown in all three figures.

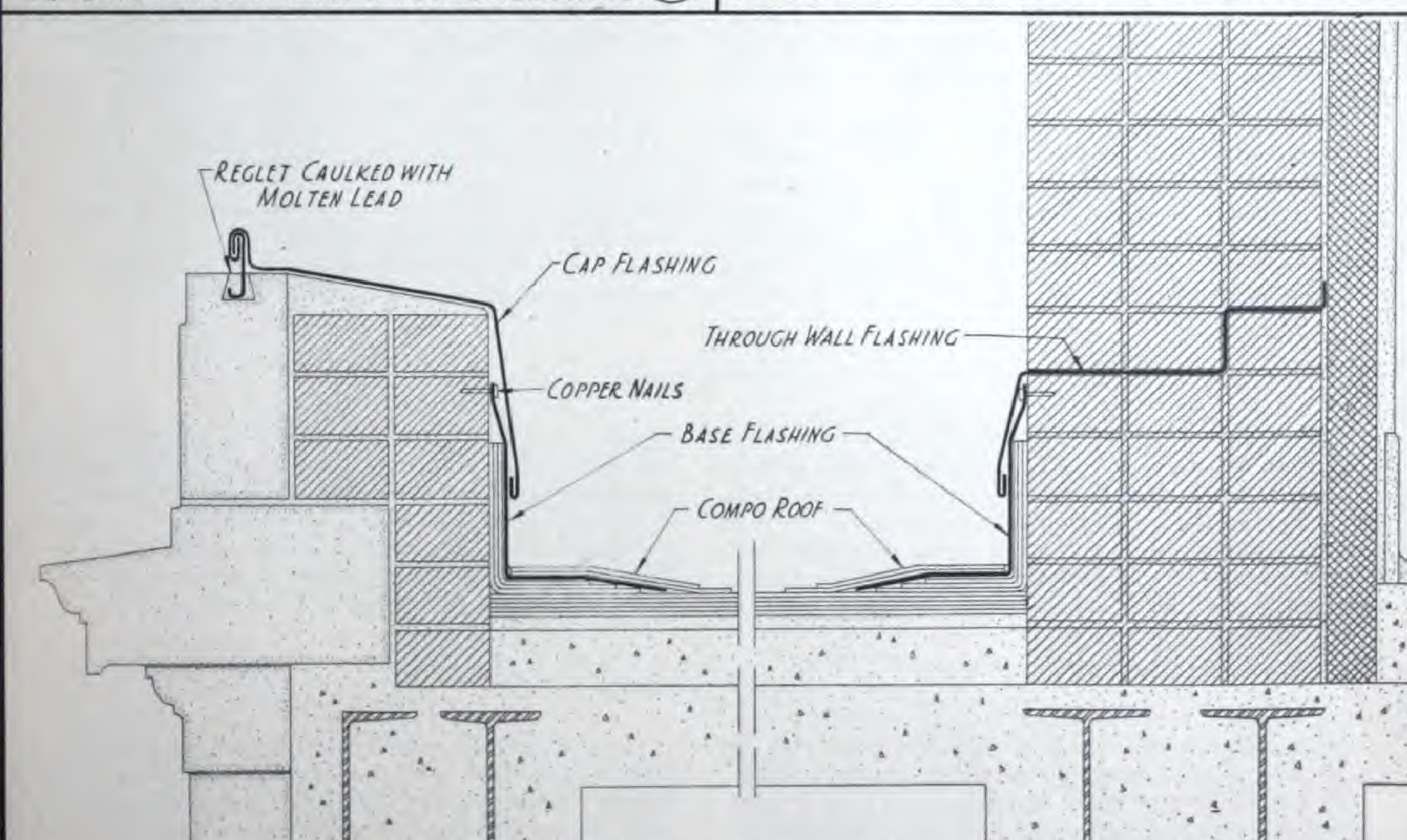
See also Note on page 52



FLASHING - STUCCO ON WOOD SHEATHING (78)



THROUGH FLASHING - STUCCO ON MASONRY (79)



FLASHING - SET BACK IN FIREPROOF CONSTRUCTION FIG. 80

WALL FLASHINGS

Through Wall Flashings

With the advent of structural steel came the development of the skyscraper. Bearing walls were no longer necessary since each floor was independently supported. Masonry walls, therefore, became mere curtain walls, to be carried higher and higher into the realm of high winds and driving rains. Previously such walls had been virtually waterproof, but the new conditions coupled with high-speed construction made it necessary to provide increased protection against penetrating moisture. One phase of this is the "through flashing." Previously when a flashing finished against a wall, it was necessary only to carry it into the masonry far enough for fastening. Now, in large buildings, it is important that the flashings be continuous through the walls and be turned up between the wall and furring. This forms a pan which acts as a cutoff for water. See Figs. 74, 79, and 80 for previous examples of through wall flashings, and page 62 for "interlocking" types.

Fig 81 shows three methods of constructing through wall flashings in brick parapet walls. Each has certain advantages.

In Detail A the flashing is carried through by being stepped up a brick at a time. This provides a cutoff for vertical seepage through the masonry, deflecting it toward the back of the wall to drain onto the roofing. The flashing tends to weaken the bond in the masonry, however, and a strong shearing force would dislocate the wall along the flashing line. In this construction with flat sheets special care must be taken that a good masonry job is obtained at the flashed joints, or the interlocking type of flashing described on page 62 should be used.

In Detail B the flashing is carried through the wall at the same plane, except for being keyed over one brick. This has the advantage of not introducing a continuous line of possible shear, but part of the seepage coming through the vertical mortar joints is turned toward the face of the wall, which is apt to be unsightly. However, this may not be serious.

In Detail C a method is suggested which uses separate flashing pieces, thereby giving minimum interference with the masonry bond and consuming less material. The seepage cutoff is not as perfect as in the details to the left as it is possible for moisture to work down past the flashings at the vertical joints. The major portion will be cut off, however, and is deflected to the two faces of the wall.

The method shown in Detail A is also applicable for building walls which are not parapets. In such cases the flashing is turned up at the inside face as shown at the right of Fig. 80. Details B and C deflect seepage in both directions and hence are not recommended for main building walls where all moisture must be turned toward the outside. See also page 94.

Fig. 82. When a parapet wall is surmounted with a coping stone, through flashing should be provided under the stone. Since the metal sheet breaks the bond between the coping and the masonry, dowels are required to prevent the stone from becoming loose.

The dowels are built into the masonry and project above the top of the wall to fit into holes drilled into the bottom of the coping. The flashing sheet is cut at the points of penetration and the surplus metal turned up against the rod. A copper collar is then dropped down over the dowel and soldered to the flashing. The collar consists of a ring of flat metal to which a sleeve the diameter of the dowel has been soldered. The flashing turns down on the building side of the wall and laps the base flashing or copper sheathing at least 3". If the wall is more than 24" high it is desirable to apply the sheathing with standing seams as shown, with a cap and base construction at the bottom. When the wall is faced with stone the coping flashing is carried to within ½" of the face; if there is no stone facing, the flashing is turned down ½" on the outside of the brick. The stone coping should project 1" over the wall on each side. The sheathing and the base flashing may also be locked as shown in Fig. 42C.

Water Table

Fig. 83 shows method of flashing the base of a frame building where a projection (sometimes called a water-table) is formed at the upper surface. A brass edge-strip first is secured to the wood by brass screws or nails and the copper flashing hooked over this strip and extended up on the sheathing and secured by copper nails not more than 8" apart along the upper edge. A cheaper and less efficient method is by nailing along the lower edge only. In either case a drip should be provided to prevent rotting of the woodwork. Four inches up on the sheathing is sufficient when the shingles are doubled at the bottom of the wall, but more is needed if shingles are but single course and the copper must be covered by the second course.

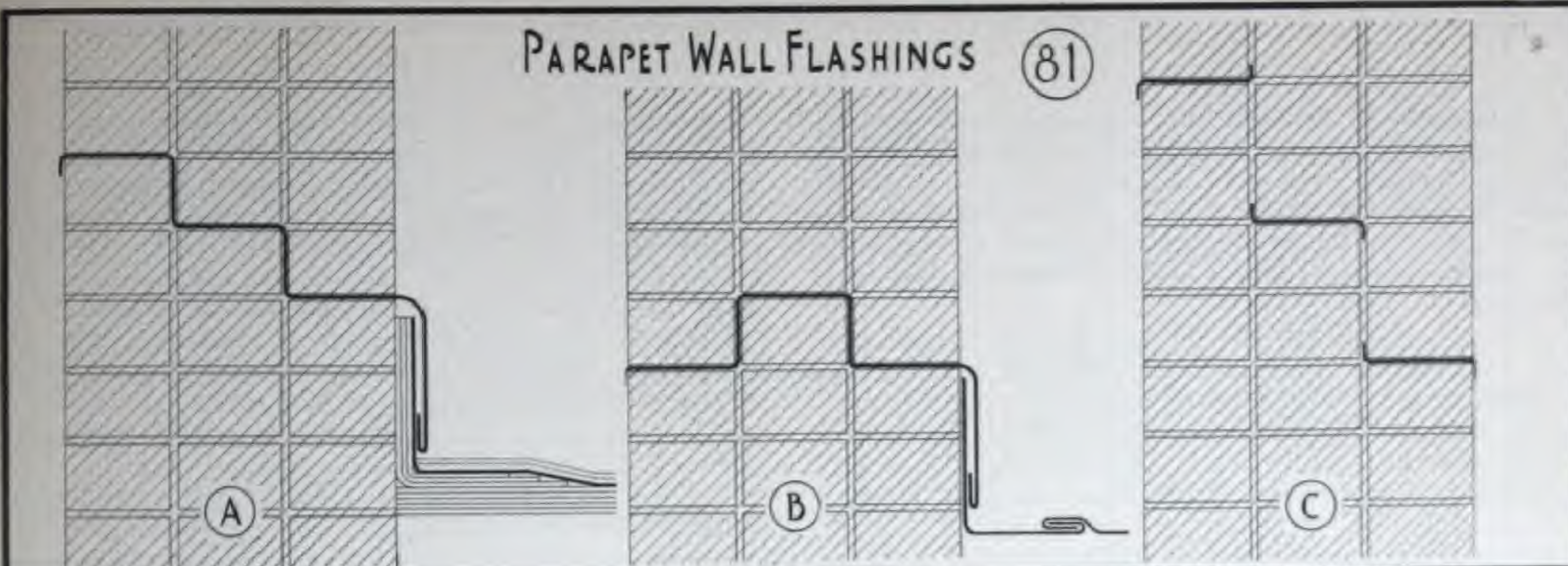
Copper Copings

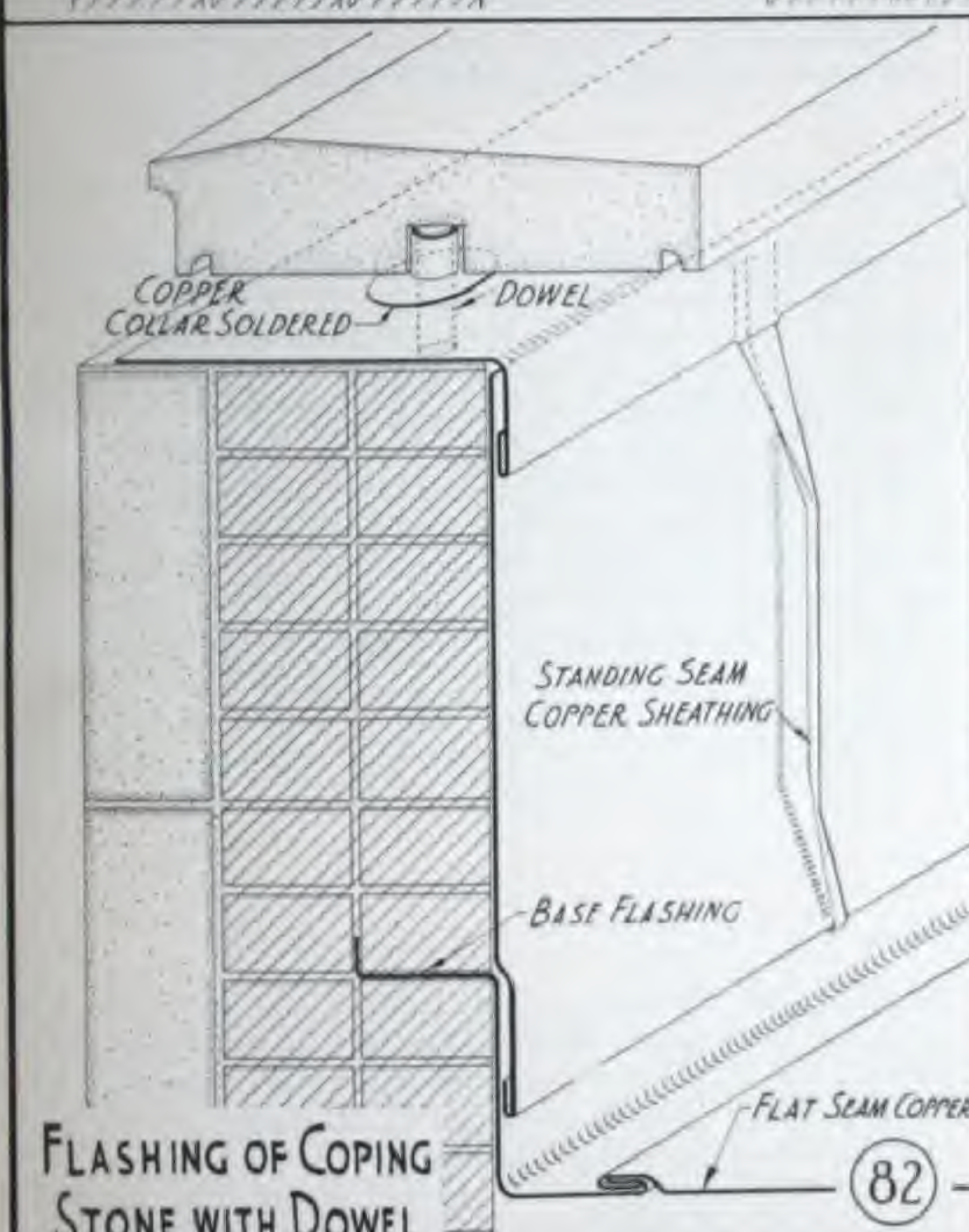
Figs. 84 and **85** show how masonry walls may be protected against seepage by means of copper copings.

In Fig. 84 narrow strips of copper, not over 8' long, are secured with non-ferrous nails into the mortar space between the bricks. The bottom edge of this strip is turned out, as shown, and the copper cap is locked into it. Sheathing or flashing of the inside of the wall can be turned into the same lock. The top of the wall should slope slightly, to drain inward.

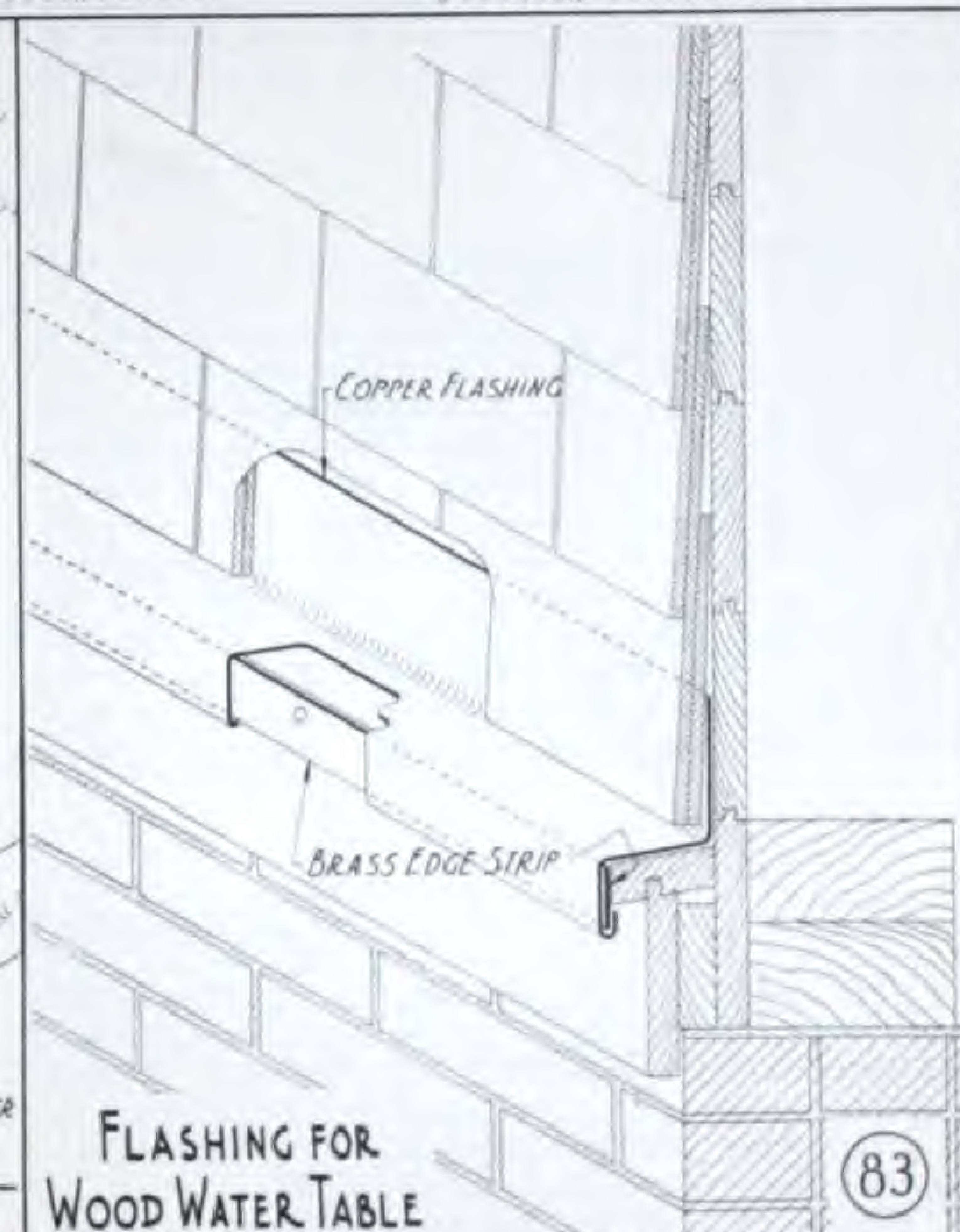
In the alternate method, shown in Fig. 85, the wall first is topped with a wood coping set in mortar and bolted to the wall at 3' intervals. This then is covered with the copper cap, the overhang of the wood coping allowing the screws or nails to be placed underneath where water cannot enter the holes in the metal. This does away with soldering the screw heads. The cap flashing also has a drip on the outside which keeps the wash away from the brickwork. (See Fig. 88.)

Parapet Wall Flashings (81)

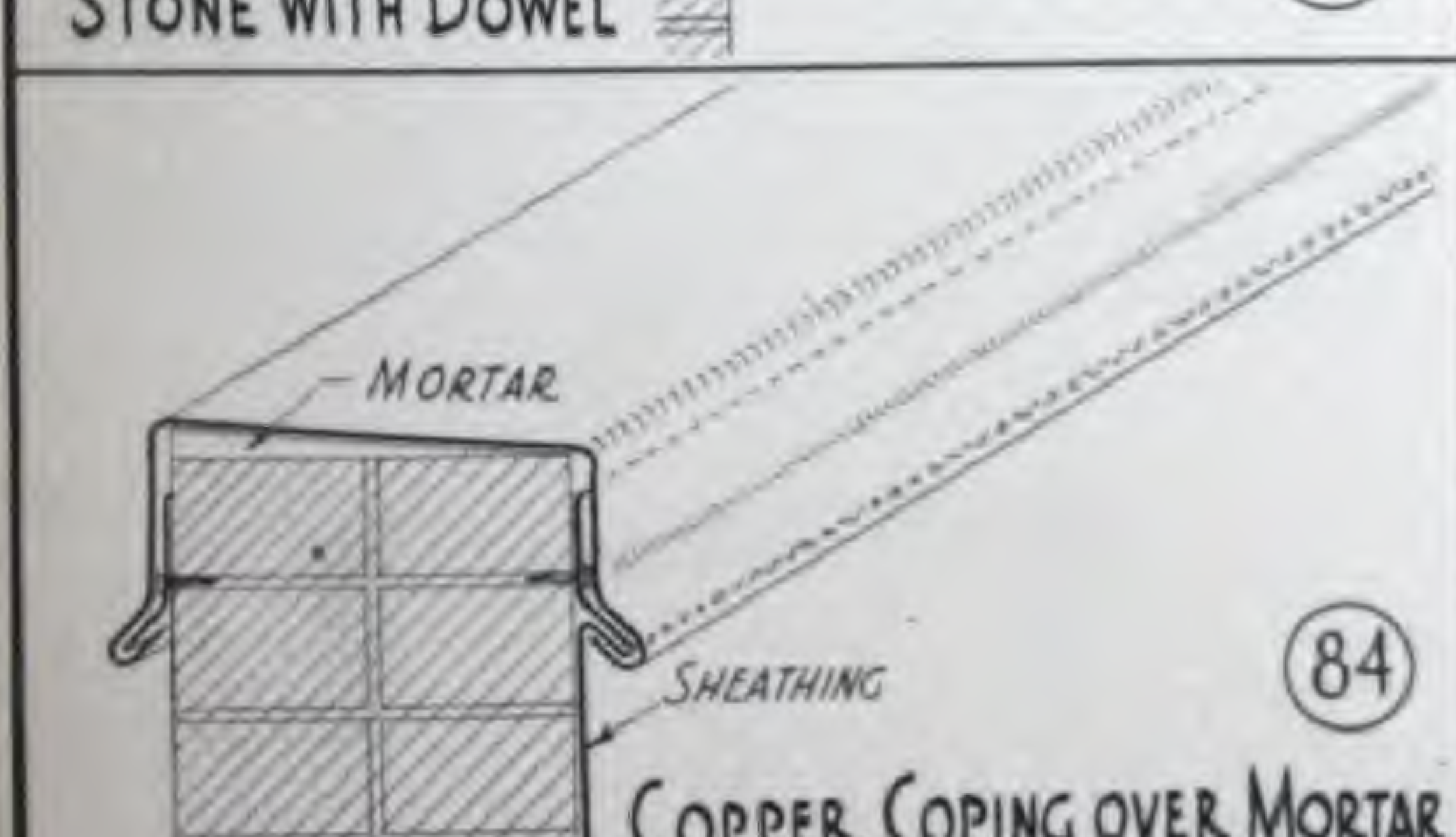




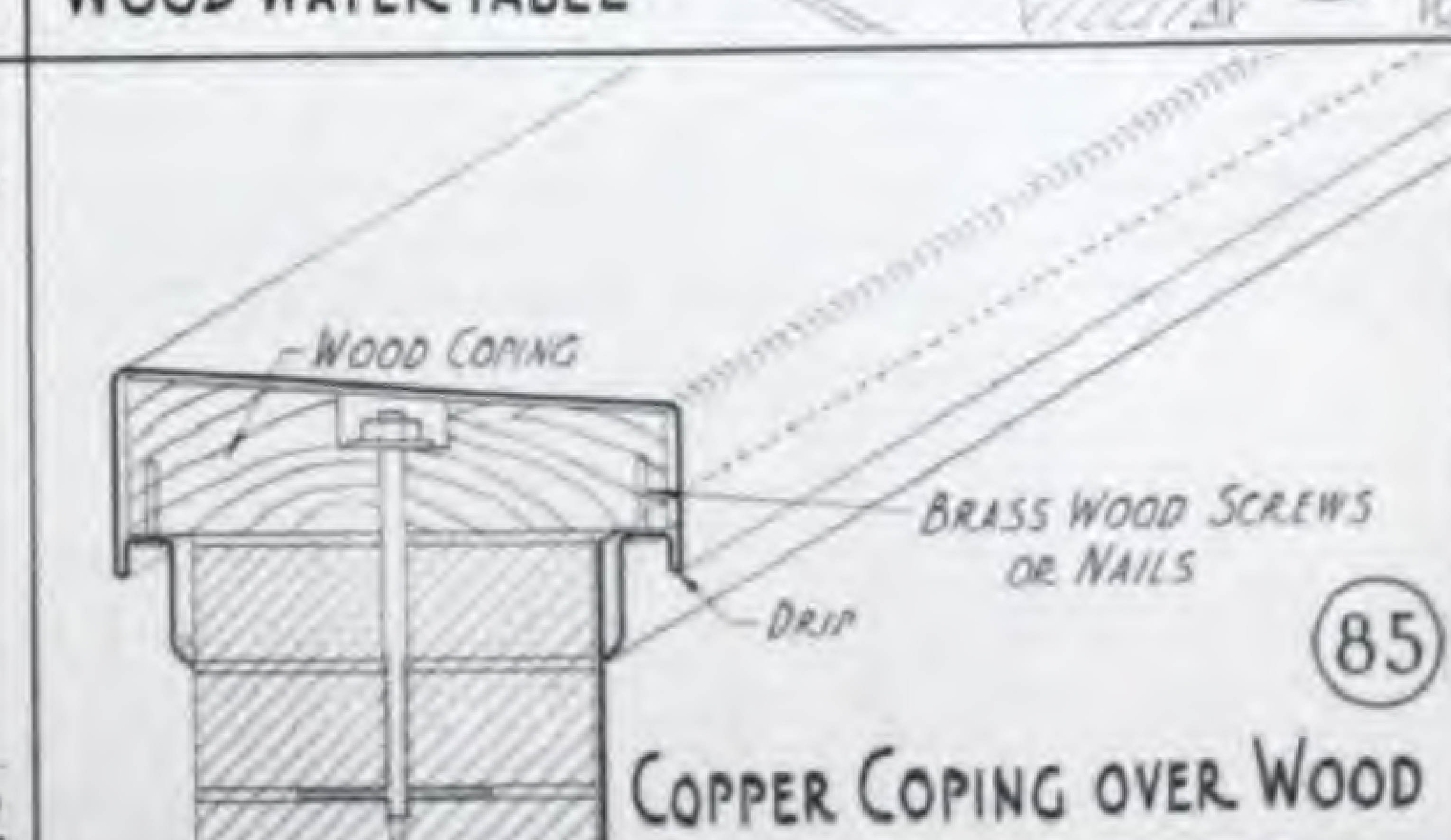
Flashing of Coping Stone with Dowel (82)



Flashing for Wood Water Table (83)



Copper Coping over Mortar (84)



Copper Coping over Wood (85)

WALL FLASHINGS (CONT'D)

Old and New Walls

Figs. 86, 87 and **88** show the methods of flashing between old and new walls. Where the walls are of uneven height, cap and base flashings are used. If the old wall is higher, as in Fig. 86, it is necessary to cut a reglet in the stone or to rake out a cement joint to receive the cap flashing which is then caulked with lead wool.

In new work, Fig. 87, the cap flashing is built into the masonry as erected. The method of finishing the cap flashing by folding the edge back gives stiffer construction. At "A" is shown the fastening used with walls sheathed with metal. The flashing, formed as shown, is secured to the edge of the wood plate by brass screws and lead washers about 8" apart. "B", "C", "D", and "E" are additional interchangeable methods of fastening base flashing. At "B" the flashing is nailed to the woodblock and a fold formed which is turned down over the nails. The nails are about 8" apart. "C" shows the edge strip method of fastening the flashing. The brass strip, ⅛" thick, is screwed to the block and the flashing is hooked over it. This gives a stiff clean edge. The method at "D" is simpler and less expensive than "C", but is less rigid. The edge strip is formed of a nailed double fold of copper. "E" illustrates an excellent method of fastening. The 1" overhang at the sides allows the flashing to be secured on the protected under side. No edge strip is needed and the drip edge formed in the flashing keeps the wash from the wall. The screws or nails are about 8" apart.

In Fig. 88 is presented the construction when both walls finish at the same height, and the drawing is self-explanatory. If the width of the copper cap sheet exceeds 24", a crimp or standing seam should be provided at the center to permit movement.

Drips and Edge-strips

Fig. 89. At the outer edge of walls, cornices, and other projections flashings should be secured or finished to form a drip edge so water will not run down the face of the construction. As illustrated in Fig. 88, it often is possible to form the flashing itself into a drip. Four methods employing separate fastenings are shown in Fig. 89. Nails or screws should be 8" to 12" apart.

Fig. 89A uses an edge-strip consisting of a piece of brass ⅛" thick by 1¼" wide fastened to the supporting face by brass screws and placed so the sheet can be hooked under it about ⅜" to form a lock. It usually is placed to project slightly below the sheathing or the upper fillet of the molding to form a drip. This is used where a stiff fastening and a straight true edge is needed, as with large molded gutters and with copper cornices.

Fig. 89B shows the drip consisting of a piece of copper (at least 18-oz., preferably 24-oz.) nailed to the top of the sheathing or to the face of the molding, to which the flashing is locked. This acts both as fastening and drip and is satisfactory for all purposes for which the heavier edge strip need not be used.

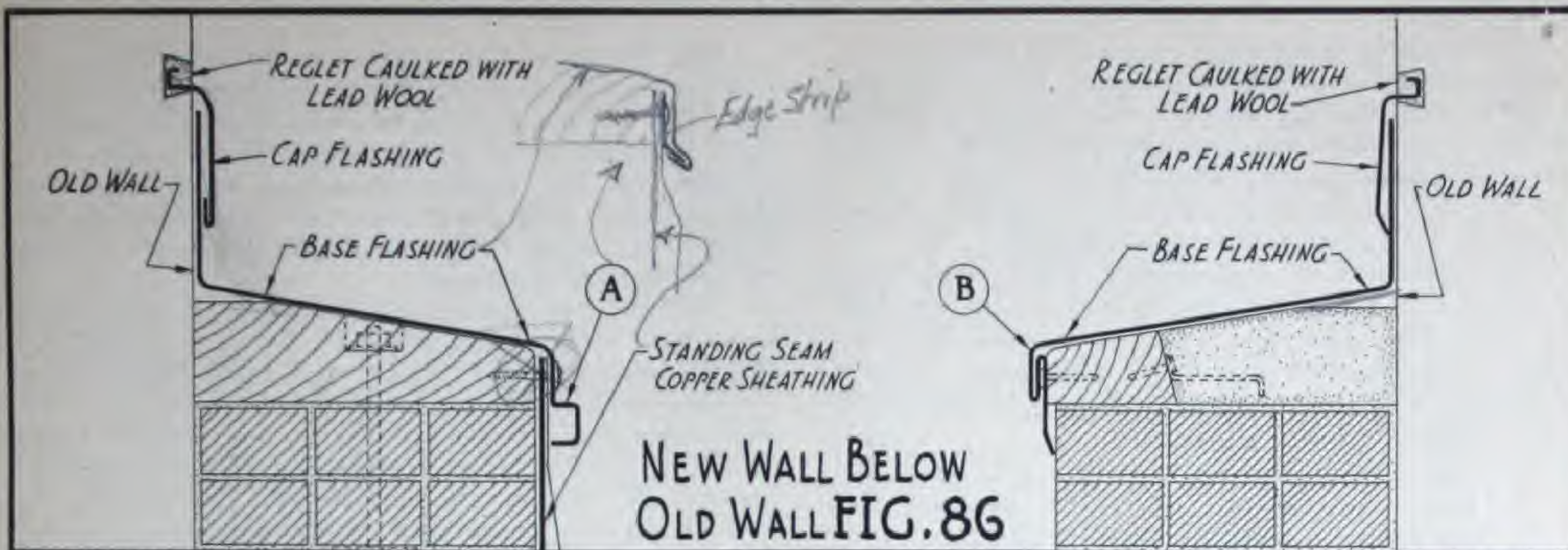
Figs. 89C and 89D show the flashing hooked over a strip of folded copper. Because this metal is doubled, 16-oz. copper can be used, and it often is more convenient to employ this method than the previous one. The strip can be offset, as in Fig. 89D, to keep the drip farther from the building. This crook can be introduced into the other method, of course, as in Fig. 90.

INTERLOCKING WALL FLASHINGS

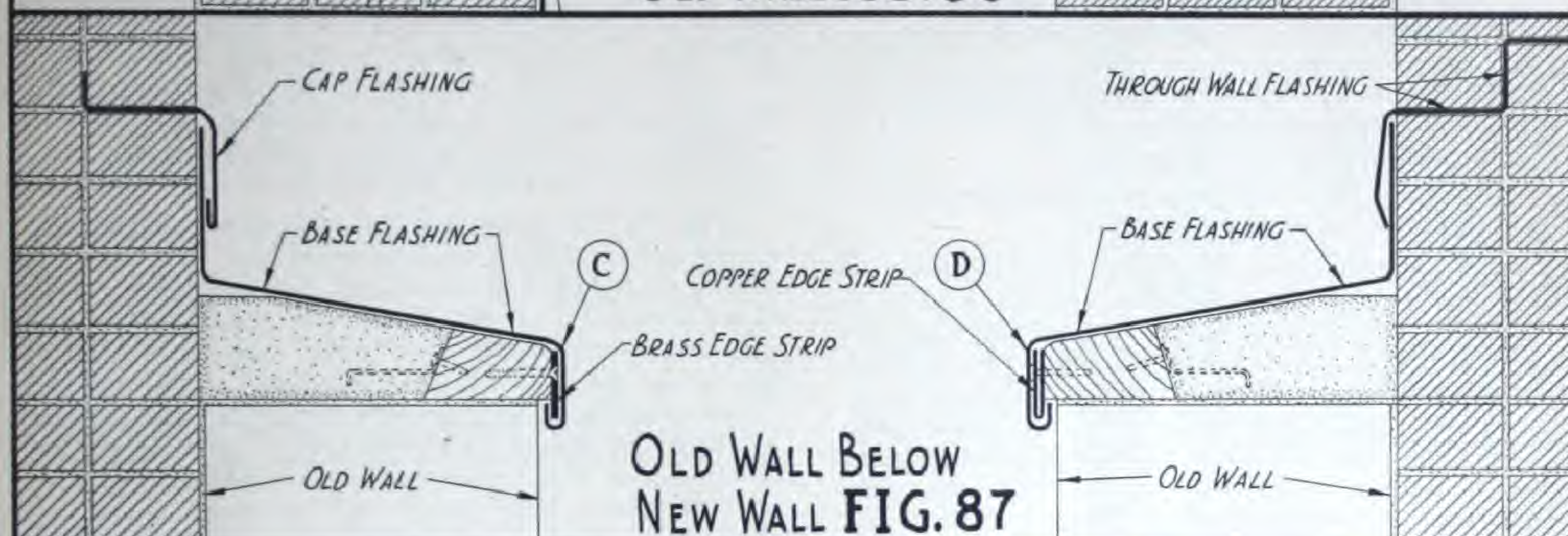
The importance of providing a complete cutoff against moisture seepage through building walls cannot be overemphasized. It has been the object of much constructive thought by many engineers during the past few years. As a consequence several excellent designs for this specialty have been evolved.

Whenever plain or crimped copper is used for the through-wall flashing, as discussed above, it is necessary to use dowels or stepping, as in Figs. 81 and 82. Otherwise the sheets through the wall would tend to weaken or break the masonry bond. However, there are on the market several patented designs of through-wall flashings which are so constructed that the masonry bond is maintained without the use of dowels or stepping. The flashing is made of specially formed sheets interlocking with the mortar to maintain an efficient bond, as well as full protection.

Such flashings, when of proper weight, temper and quality of copper can be recommended as through-wall flashings under coping stones, at lintels, spandrel beams, etc. This Association will be glad to refer prospective users to the manufacturers of these specially designed flashings, from whom full details as to their application may be obtained.

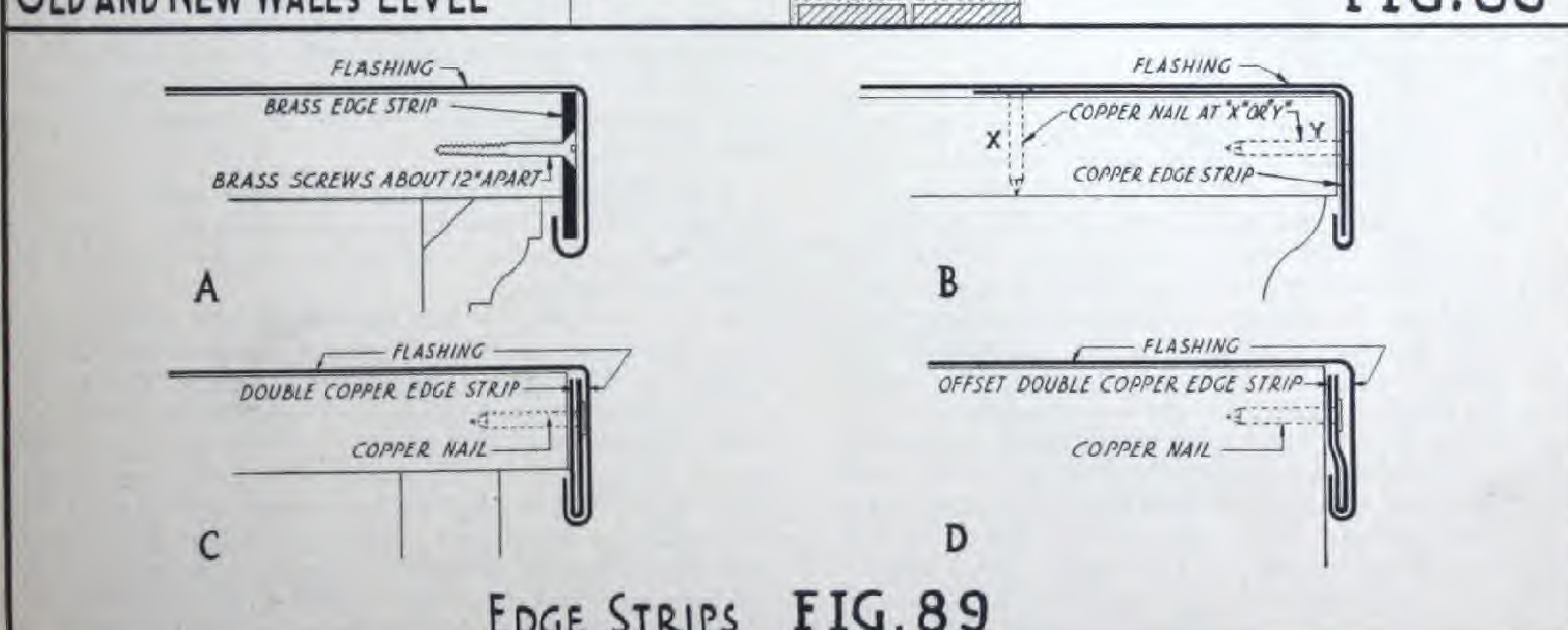


NEW WALL BELOW OLD WALL FIG. 86



OLD WALL BELOW NEW WALL FIG. 87

OLD AND NEW WALLS LEVEL FIG. 88



EDGE STRIPS FIG. 89

EAVES, GUTTERS AND EXPANSION JOINTS

The finishing of different types of copper roofs at eaves and their connection with gutters has been discussed in the Roofing Section. Eave flashing details for other types of roofing draining into gutters is here discussed, and since the methods are involved to a large degree with the construction of the gutters themselves, the two subjects are treated together.

These portions of copper sheet metal work, viz., construction at the gutters and of built-in gutters, present more difficulties and give more possibilities for trouble, perhaps, than any of the other parts. So here are reiterated certain cardinal principles which should be kept in mind.

1. Flashings and gutters are not meant to store water, but to carry it away as fast as possible.
2. Always install copper work so that it is free to move the amount required by local temperature variations.
3. Plan the design so that, where possible, joints can be loose-locked and soldering avoided.
4. Avoid nailing through copper sheets.
5. Plan the construction so water will flow over the copper and not impinge in streams.

Laying specifications issued by manufacturers of slate, shingles, and tile invariably call for a cant or batten strip under the starting course and running parallel to the eaves. The strip varies in thickness depending on the dimensions of the shingles, its purpose being to enable the second and following courses to be properly laid. The cant strip has the added advantage of raising the shingle butts away from the flashing. This is important in some localities where acid-forming atmospheres sometimes cause chemical corrosion when moisture is held by capillary attraction at the air-shingle-copper line. If the flashing is carried under the wood cant strip, the latter should be held by copper straps soldered to the flashing. Nailing the strips, of course, would puncture the flashing.

There are three general methods of handling the cant strip with shingles or slates. In each the flashing is continuous and is carried under the shingles as far as possible to permit cleating just below the first nailing. The lower end of the flashing is locked to the hanging or box gutter lining, or if there is no gutter, to an edge strip. (See Fig. 89.)

In Figs. 91 and 92 a wood strip is used over the flashing. This should be of hard wood smoothly finished and secured by 2" copper straps soldered to the flashing at 2' intervals. See Fig. 93 for further details.

In Fig. 90 the wood strip is placed before the flashing is installed. This has an advantage in that the strip can be nailed down, and that since it is protected by the flashing the quality of wood is not important. Also, there is easier drainage for any moisture which might collect under the shingles. On the other hand, it has the disadvantage over the first type in that the shingles may be in contact with the flashing, presenting a slight chance for line-corrosion. In Fig. 63 the cant strip consists of a folded or crimped copper strip soldered to the flashing. The crimp slants slightly in the direction of the roof slope. The metal strips should be laid in 4' sections, with ½" openings left between lengths as outlets for any moisture which may seep through or condense back of the cant strip. Drainage also is facilitated by laying the strips at a slight angle with the horizontal.

Fig. 90 shows the method of flashing when roof tiles are used on a sloping concrete slab roof and project but little beyond the eaves. Sometimes this flashing takes a molded form and is treated in the design as a cornice, but the application still is essentially that shown, except that the copper may be formed in two parts with a loose-lock seam joining the parts outside the first horizontal sleeper.

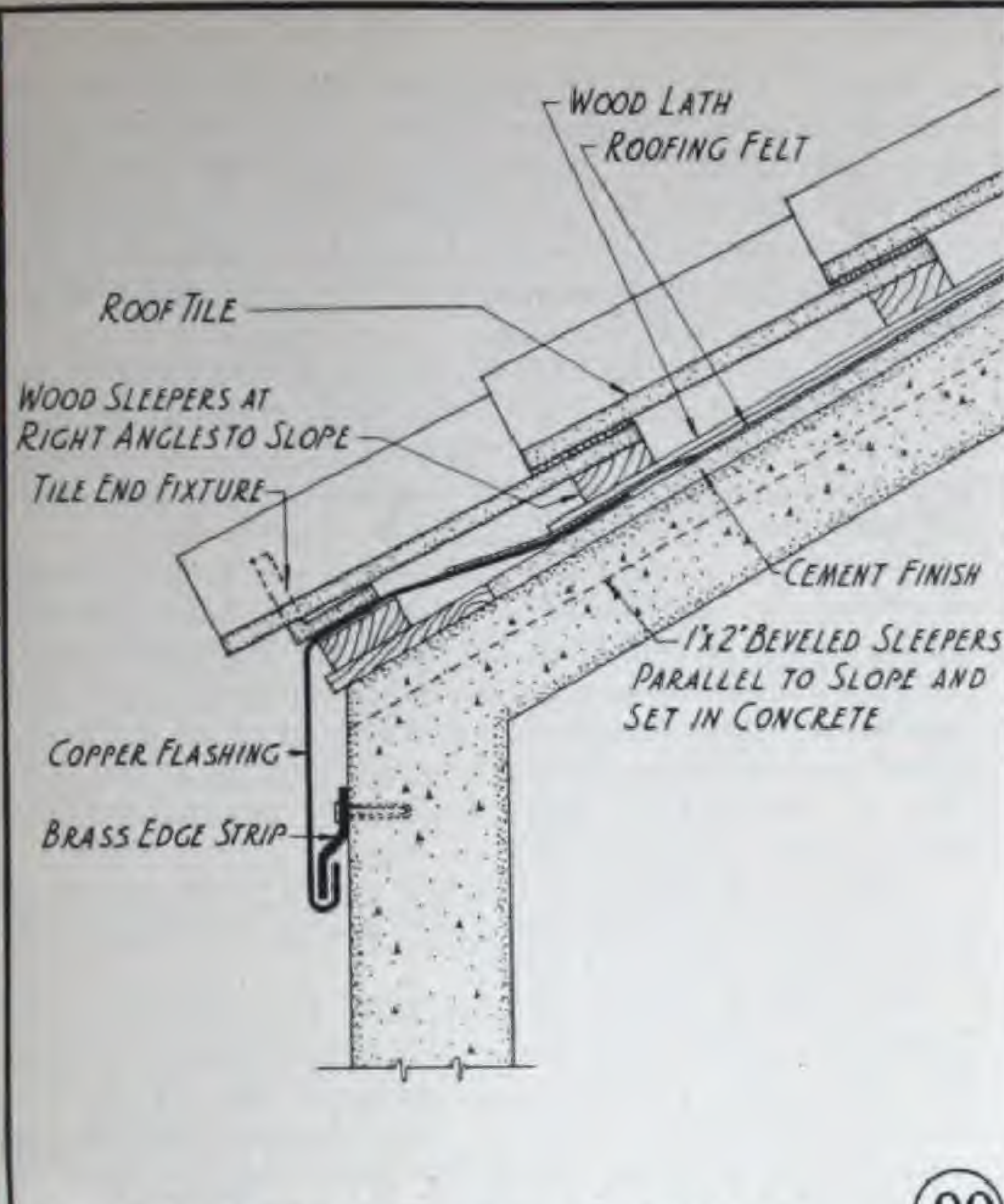
The first step in placing the flashing is to secure a brass edge-strip to the concrete, by drilling holes in the concrete about 12" apart, and using brass screws wrapped with sheet lead, or brass and lead expansion bolts. (See Fig. 103.) The holes in the concrete never should be filled with wood plugs, as the wood will dry, shrink, and loosen the edge-strip. The flashing is brought up on the wall and turned back over the first sleeper and up on the roof far enough so no water pocket will form. The high end of the flashing will be about 2" vertically above the top of the first sleeper. No flashing nailing is necessary as the weight of the tiles will hold it in place, but copper or copper alloy nails should be used to secure the tiles to the sleepers.

Fig. 91 shows one method of forming an attached gutter and securing it to a shingled roof. The upper or roof edge is turned back on itself ½" to engage copper cleats about 12" apart, which are nailed to the roof with copper or copper alloy nails. The outer edge or roll of the gutter contains a ⅛" brass or bronze bar. To this are riveted long copper straps of $\frac{3}{16}$" metal about 30" apart extending up on the roof 3" or 4" above the inner edge of the copper gutter. To give them added strength these often have a 180° twist in the portion above the gutter. Each strap is secured to the roof by two brass wood screws or nails. The wooden cant strip inserted to raise the butts of the first course of shingles is held by copper cleats soldered to the gutter flange. (See Fig. 93.) While desirable for this form of gutter to be supported from below as well as from above, and a copper drip provided, this is not vital.

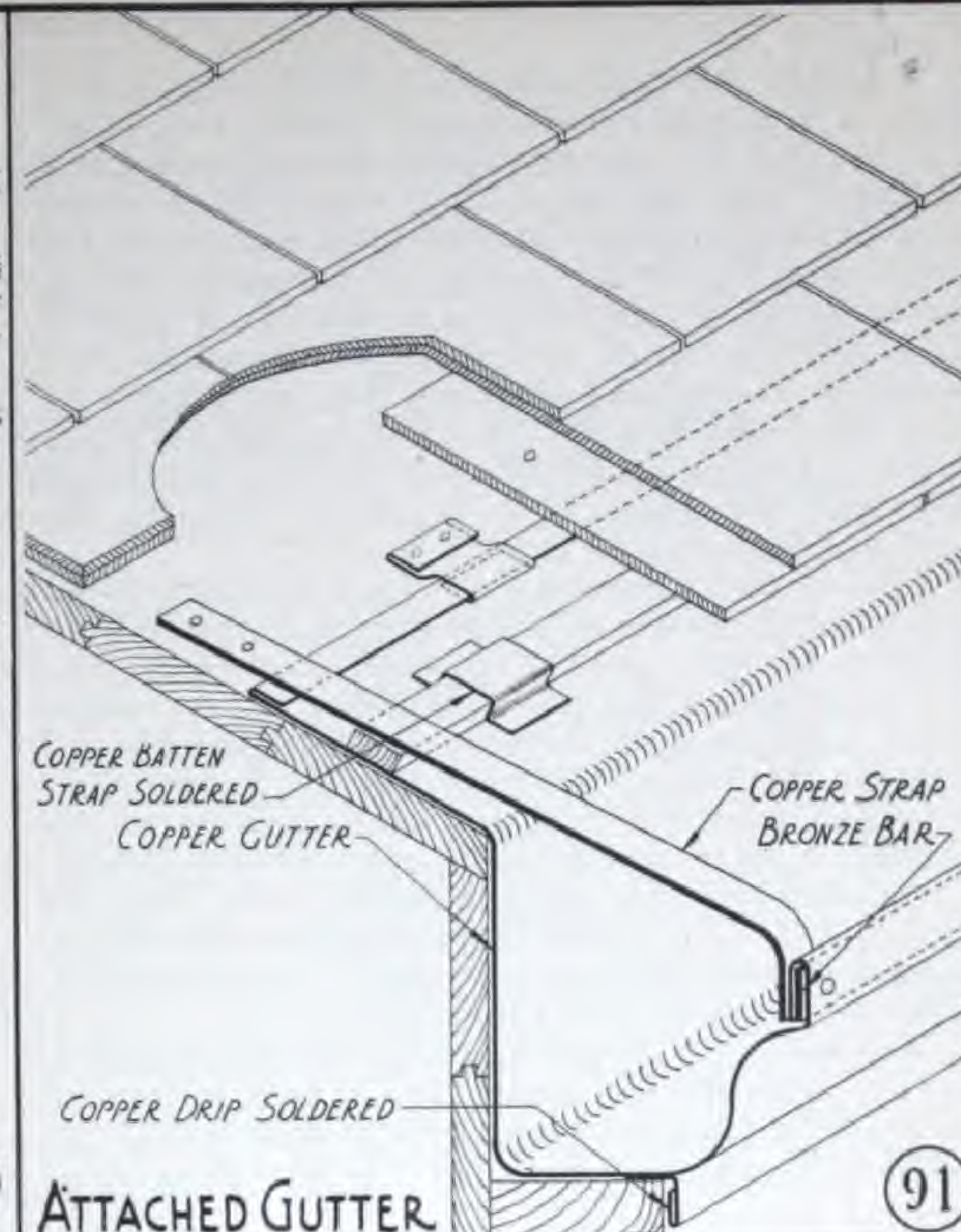
In long runs of molded gutters it sometimes is necessary to install false bottoms, or inner linings, to get the proper slope to the outlet. The gutter itself must hang level and true to form the cornice. Such inner linings are formed of not less than 16-oz. copper to fit the gutter contour and are set and soldered to the sides to provide a sloping floor. Where possible, such construction is to be avoided because of expense both for material and labor.

Fig. 92 shows another type of gutter called a "Pole Gutter." This is known in some localities as a "Gutter-Strip" and the gutter is placed on the roof instead of suspended from it.

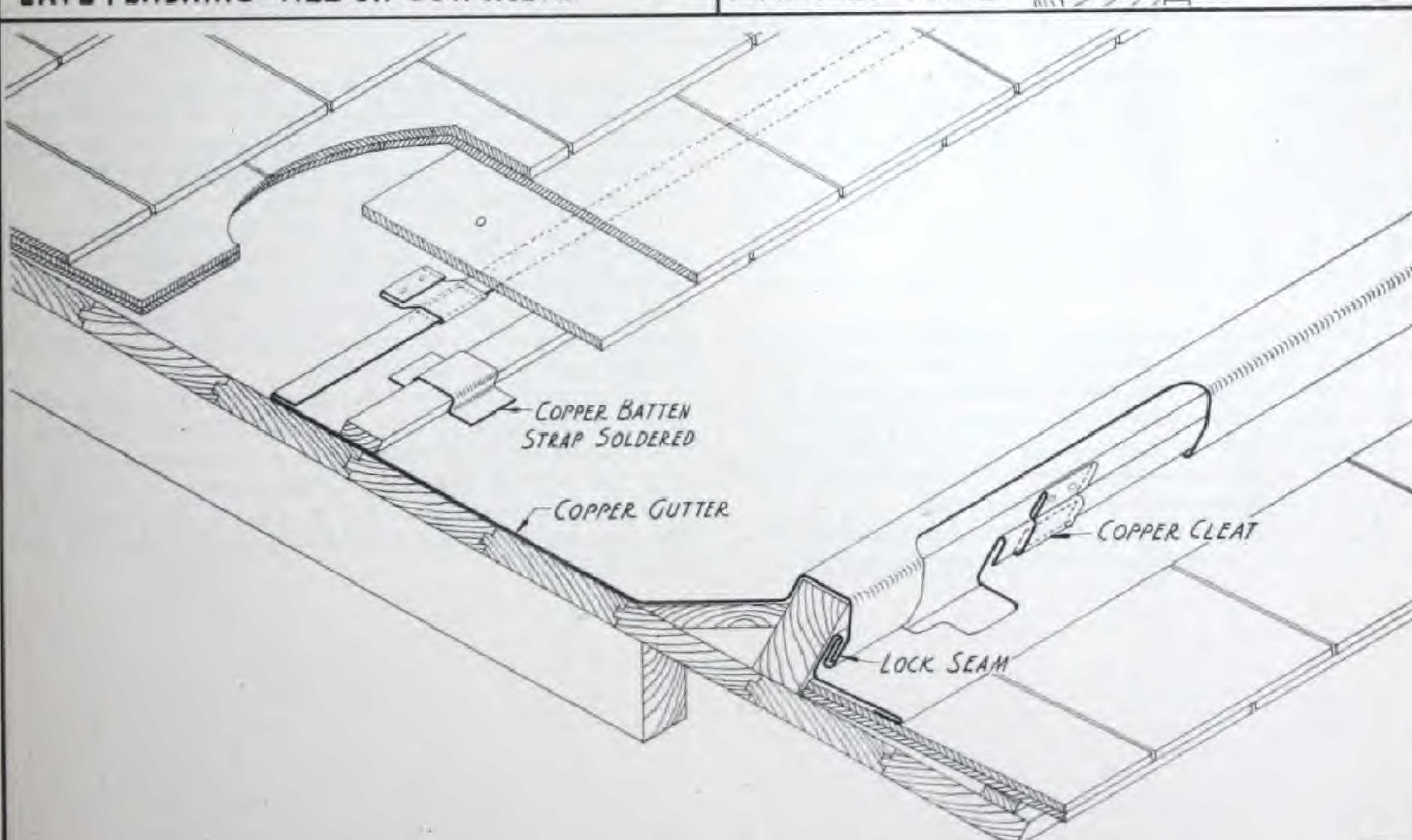
A 2" x 4" pole is run parallel to the eaves, over which the copper is formed with drainage provided by a gusset in the gutter sloped to the leaders. The flashing is in two pieces loose-locked together and cleated to the lower side of the wooden pole as shown, on the top, or just under the top outer edge. The upper edge of the flashing is turned back on itself and secured to the sheathing by copper cleats and nails. The lower piece should lap the shingles below the pole at least 4", and also has its lower edge turned back ½" for stiffness. If necessary it is fastened to prevent wind lifting. The shingles along the upper edge should lap the copper at least 4", and the copper should be covered by at least two thicknesses of shingles.



(90) EAVE FLASHING - TILE ON CONCRETE



(91) ATTACHED GUTTER



(92) POLE GUTTER

Fig. 93. Two general methods can be employed in lining a box gutter with copper sheets. One, illustrated in Fig. 93, uses continuous sheets installed as a "floating" unit; the other, small sheets cleated down as in flat-seam roofing. Expansion and contraction are cared for in Fig. 93 by leaving all extremities free so the entire lining can move as a unit. If the gutter exceeds 30′ in length, one or more expansion joints should be inserted at high points with drainage away from the joints. (See Fig. 94.) The longitudinal loose-lock seams should not be dressed down tight but should allow free movement. Cross seams are soldered flat locks not cleated down.

The wooden batten at "A" raises the butts of the lowest double course of shingles or slates away from the flashing. This prevents moisture being retained at the air-shingle-copper line by capillary action, which might cause chemical corrosion in acid-forming atmospheres. The batten strip goes over the flashing, and is held in place by 2″ copper cleats soldered to the flashing. Nails of course, would puncture the flashing.

As is shown in the isometric sketch, a ¼″ diagonal joint, as at "D", should be left between the batten lengths, thereby allowing drainage for moisture which might collect back of the batten strip.

The flashing is cleated back from the shingle butts, leaving room for the batten, and a hook formed at "B" to allow the gutter-lining to be loose-locked to the flashing. Ideal gutter design has a vertical distance of at least 2″ between this lock and the elevation of the outside edge of the gutter. Water, then, cannot back up to the seam "B" in the event of outlet stoppage, and the seam can be unsoldered to allow for expansion and contraction. The seam, however, should be filled with white lead paste so water will not enter from capillary action or melting snow.

The gutter lining should be fitted loosely to gain full advantage from the movement allowed by the loose-lock seam. This is especially true at corners where the copper should be rounded into place, with the insertion of wooden cant-strips, if necessary.

To further insure that freedom of movement is not restricted, it is sometimes advisable to separate the gutter lining proper from the part turning down over the eave. This can be done by using separate sheets for the two portions, joined by a standing seam on the horizontal part between them, the seam folding to the outside, or joined by a loose lock seam on the outside slope, as shown in the circles in Fig. 93.

The gutter lining is finished at "C" by hooking over a copper or brass edge strip previously placed with brass screws about 12″ apart.

In localities where ice may form to a considerable depth in a gutter, it is important to construct the outside face with a slope. This permits the ice to lift instead of causing a thrust. Such design generally is desirable in any case, since the flatter angles allow a greater freedom of movement to the copper.

Gutters at Parapet Walls

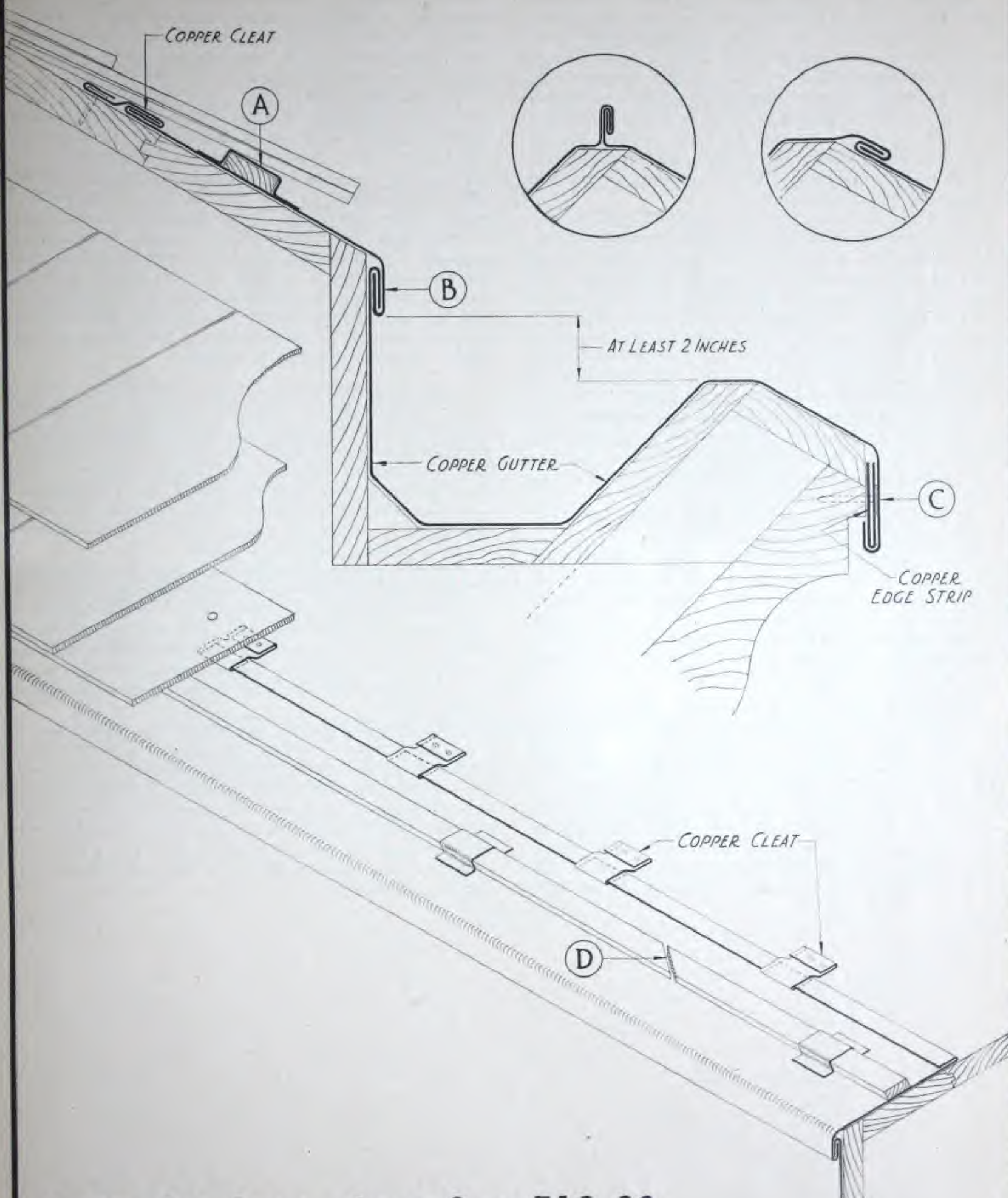
There is an increasing tendency today to finish sloping roof areas behind a parapet wall. In such construction the gutter is usually fairly wide and is more in the nature of a cricket. It covers the space between the main roof area and the parapet wall. As it will be pitched at a very low slope, flat seam construction is called for, the construction being in accordance with details for that type of work given on pages 34 and following.

There remain three important considerations which must be given special attention. The first of these is the connection between this gutter and the main roof area. The second is the necessary provision for longitudinal movement where the length of gutter is 30 feet or more. The third is the accomplishment of a watertight joint between the gutter and the parapet wall.

As to the first of these, what has been said in general as to the connection between other types of roof areas and gutters applies here. It is always advisable that this shall be by a loose lock if at all possible. This loose lock, of course, should be high enough up the slope so that water cannot possibly back up over it. Otherwise it should be filled with white lead.

In regard to the second item (provision for longitudinal movement), this also follows along the other lines of standard procedure. The outlet should fit loosely into a sleeve so that movement at that point will not cause trouble. Then expansion joints should be provided at high points between outlets.

In regard to the third detail—that of the connection between this type of roof area and the wall flashing—this should be so arranged that water cannot back up over the base flashing. For this purpose it is well to provide scuppers as shown in Fig. 111 on page 79. Through-wall flashing instead of partial flashing is also recommended.



COPPER BOX GUTTER - SHINGLE ROOF FIG. 93

Fig. 94 shows an expansion joint for built-in gutters. These joints should be placed at the high points of long gutters when the linings are installed of continuous sheets as floating units. They care for longitudinal movement due to temperature changes. To make the joints effective, the copper must be installed so all movement is transmitted freely along and taken up at the joint. This means the locks making up the lengthwise boundaries of the lining must be unsoldered, and not tightly malleted. The lining should be inserted loosely with rounded corners.

The design of this type of expansion joint is discussed on page 14 and Fig. 94 shows its construction. The headers are soldered to the two sections of the lining and are spaced as required by the design. (See center Fig. 95.) They are carried up above the gutter so water cannot enter the loose-lock joints where the cap engages the flanges. A water spreader as shown at "B" can be soldered on top of the cap to deflect into the gutter such water as falls on the cap, preventing it from running down the face of the building.

Detail A shows method of finishing cap at the roof end. The cap is provided with ½″ extra metal which is folded back just under the flanges of the two sections of the gutter lining, and the roofing copper is locked in between all flanges and the body of the cap.

At the outer edge, the cap merely folds over the outside gutter lock as shown at "C".

When the gutter finishes in a copper cornice, the cornice also should be broken at the expansion joint. So the break may be invisible from the ground, it is covered with an auxiliary copper strip soldered to one side and wide enough to slide back and forth over the other, as in the attached gutter in Fig. 96. Sometimes a cap is used, loose-locked to each side.

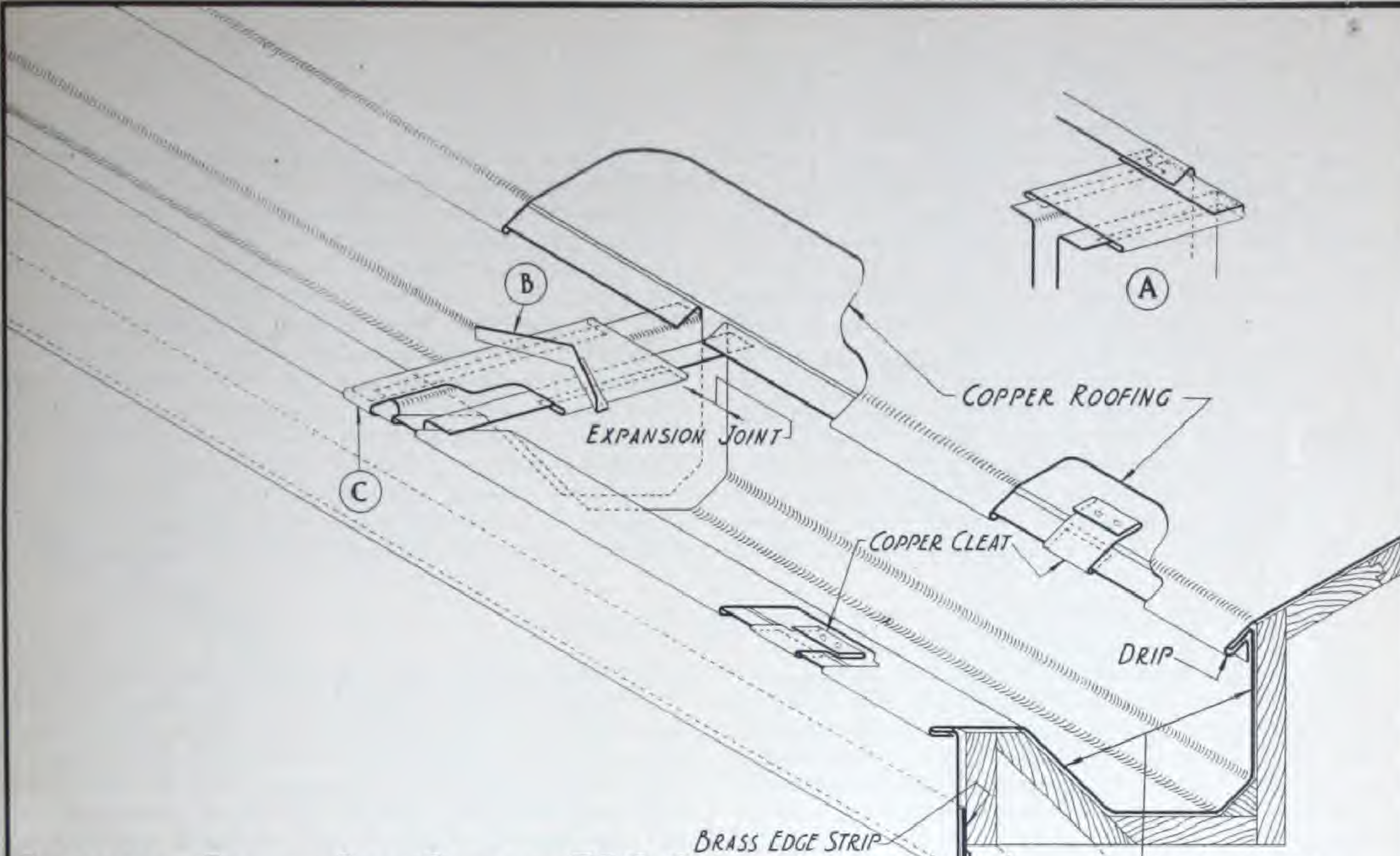
Fig. 95. In box gutters having linings of continuous sheets installed as floating units, if all movement is not cared for by means of expansion joints at high points, the linings must be free to move at the ends. This can be done in many ways, one being shown at the sides of Fig. 95. It is, of course, essential that the joints along the outside and roof edges of the gutter permit movement of the lining. The inside edge should be loose-locked to the roof or roof flashing, and on the outside edge the lining can be hooked over an edge strip. If a reglet is required at the outside, to conceal the metal, a separate copper strip should be caulked into the reglet, to which the gutter lining can be locked loosely with a flat seam. This seam is placed along the top of the cornice and is caulked with white lead.

Header expansion joints must be placed at high points in the gutter. If a number are installed, there must be leaders or drains between them. In long runs the design is such that a combination construction involving a center joint and free ends sometimes is advisable, as suggested in Fig. 95, to avoid a number of leaders down the front of the building. In all cases, the distances "A", "B", and "C" must be computed carefully for local temperature conditions. A sample computation is given on page 15 for a joint with fixed ends. If the ends are free, they should be designed to take up half the movement. Locks and flanges must be large enough to accommodate the movement required without becoming unlocked.

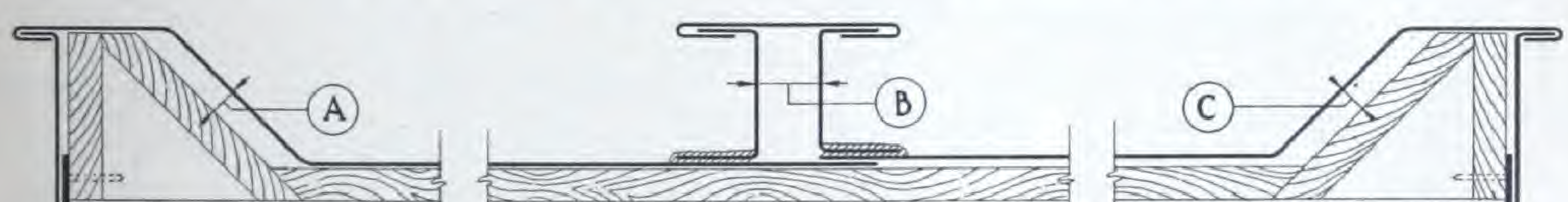
Fig. 96 shows an expansion joint in an attached gutter installation. It is exactly the same in principle as the type used in box gutters, and its design is similar. Hanging gutters installed as units entirely detached from the roofing material, and which are free at the ends, will not need such expansion joints if installed with slip joints every 50 feet. If two sections of gutter meeting at a corner are joined so as to be continuous, neither section is free at that point.

In the joint shown in Fig. 96 each gutter section has a header soldered in with a flange bent at the top. A cap then slides over the flanges and is provided with a water-spreader. (See Fig. 94.) The method of determining width of cap and the distance between headers is described on page 15. These joints must be placed at high points with drainage away in both directions to the leaders.

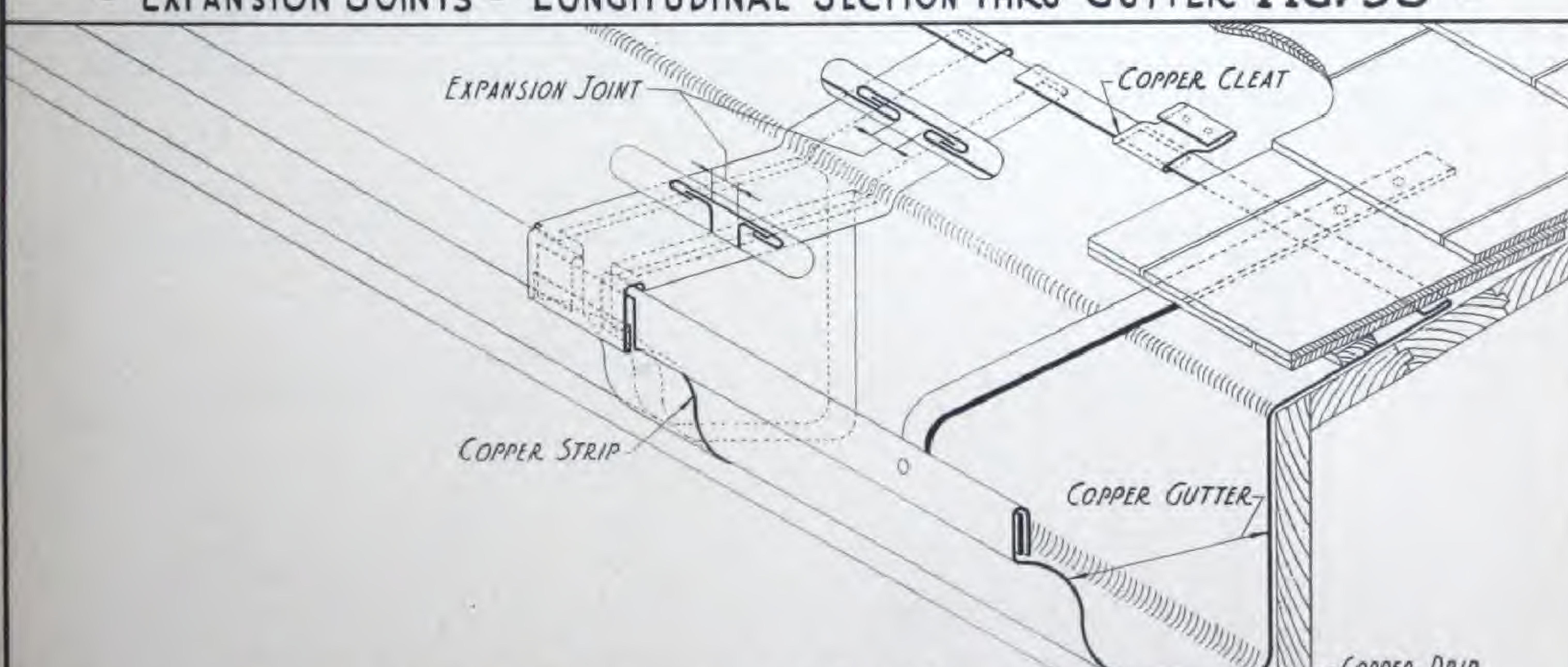
Since hanging gutters are not hidden from view, it is usual practice to conceal the gap at the joint with a copper strip, as shown. The strip is formed to the shape and size of the gutter and is soldered along one edge to one of the gutter sections. The other edge merely laps over the adjoining section the distance required by the movement at the joint, and is free to act as a slip connection. This type of gutter is discussed further in Fig. 91. See page 64.



EXPANSION JOINT - BOX GUTTER FIG. 94



EXPANSION JOINTS - LONGITUDINAL SECTION THRU GUTTER FIG. 95



EXPANSION JOINT - ATTACHED GUTTER FIG. 96

Saw-Tooth Gutter

Fig. 97. In a factory saw-tooth roof, where it is desirable to obtain maximum light and at the same time avoid direct sunlight, the roof windows are placed facing a northerly direction. This means the gutter is always in shadow, which, in northern localities, permits snow to gather and remain in the gutter for long periods.

The "line of minimum shadow" shown in Fig. 97, indicates the low point to which the sun shines on the slope of the roof. The area to the left of this line receives more or less sunlight, according to the hour, and the area to the right receives none. This line as well as the angle of the face opposite to the windows varies with the design of the building and the latitude in which it is built. In every case the copper flashing should be carried up the slope at least 1′ beyond the minimum-shadow line and be fastened to the roof by cleats and also be carried up under the sills of the windows. All sharp angles should be avoided in the construction of gutters, and in those more than 24″ wide a soldered lock seam should be formed lengthwise down the center, or the lining made up of 14″ x 20″ sheets flat-locked and soldered.

Such gutters usually are subject to hard treatment as it often is necessary to shovel out accumulated snow, possibly breaking the metal with shovels or the nails in workmen's shoes. To overcome this steam coils for melting the snow probably are best. In every case there should be provision for quick drainage. Small electric heaters sometimes are placed at outlets. A 6″ x 6″ angle with edge notches, frequently is placed inverted in the middle of the gutter. The water from melting snow flows through the small notches to the outlets and is drained away. If gutters are to be cleared of snow by workmen with shovels, snow boards are essential to protect the metal from damage.

Scuppers should be provided at ends of gutters such as these, at an elevation below the lowest edge of the flashing, to prevent leakage in case of clogged outlets.

Reglets and Caulking

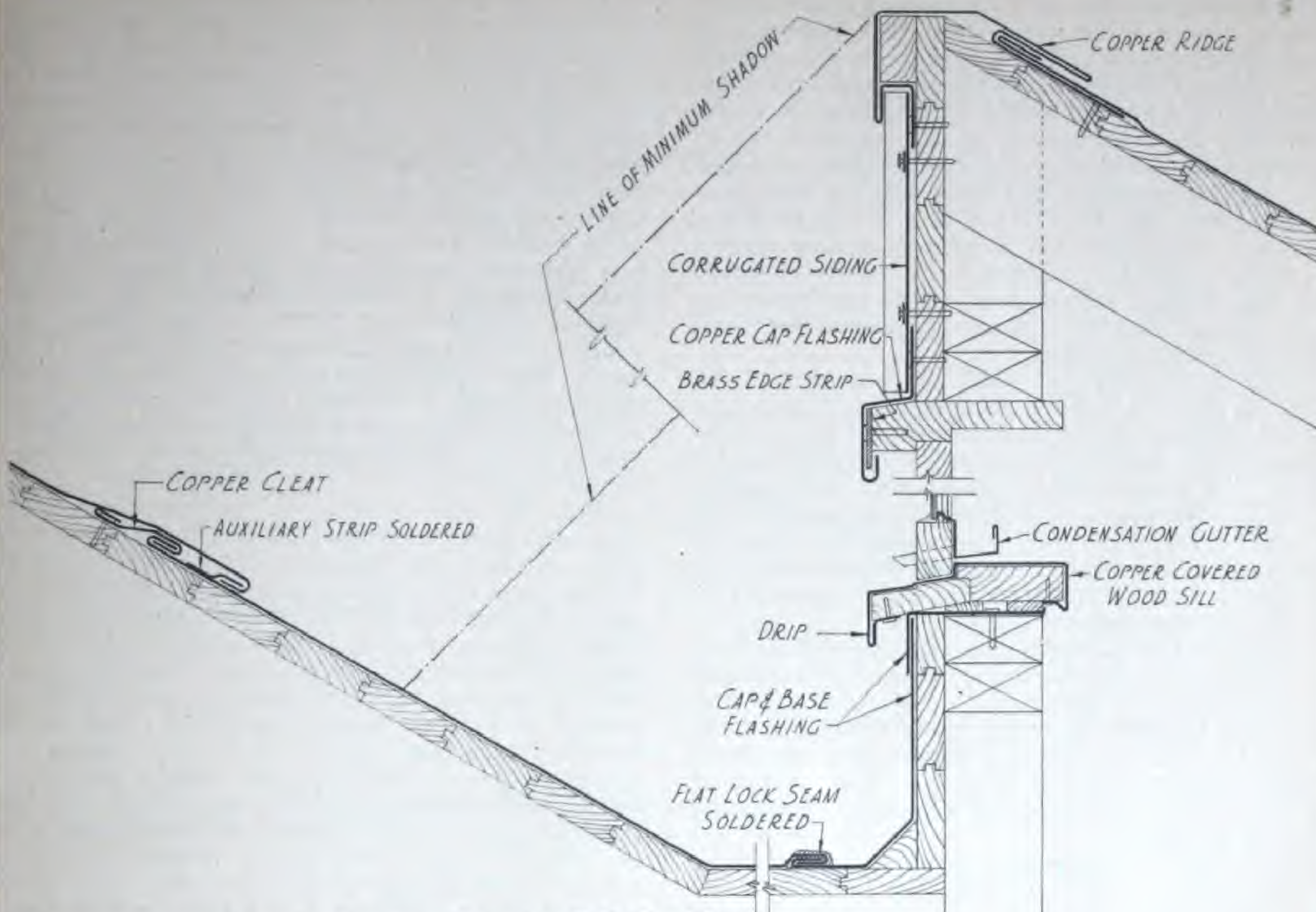
When copper flashings are laid over or against concrete or stone they should be secured into the masonry with a watertight joint by cutting a reglet approximately ½″ wide at the top and about ¾″ wide at the bottom and 1″ deep, as shown in **Figs. 98 and 99.** In concrete work the reglet is best cast when the job is poured, with or without a sheet metal insert. The surface edge should be true, but the interior sides and bottom should be fairly rough to obtain a better bond for caulking. Flaring the sides so the bottom of the reglet is wider than the top is excellent practice as it makes the joint more secure. The copper, formed as shown, is laid to the bottom of this cut and caulked in place.

Molten lead is recommended for caulking reglets in horizontal surfaces. It flows well into the cut to hold the copper firmly, does not disintegrate, and adjusts itself to temperature changes. On perpendicular surfaces, where pouring of molten lead is difficult, lead wool is used. To obtain the best results from this important operation, no matter which caulking material is used, the copper must go completely to the bottom of the reglet and the caulking must be done thoroughly.

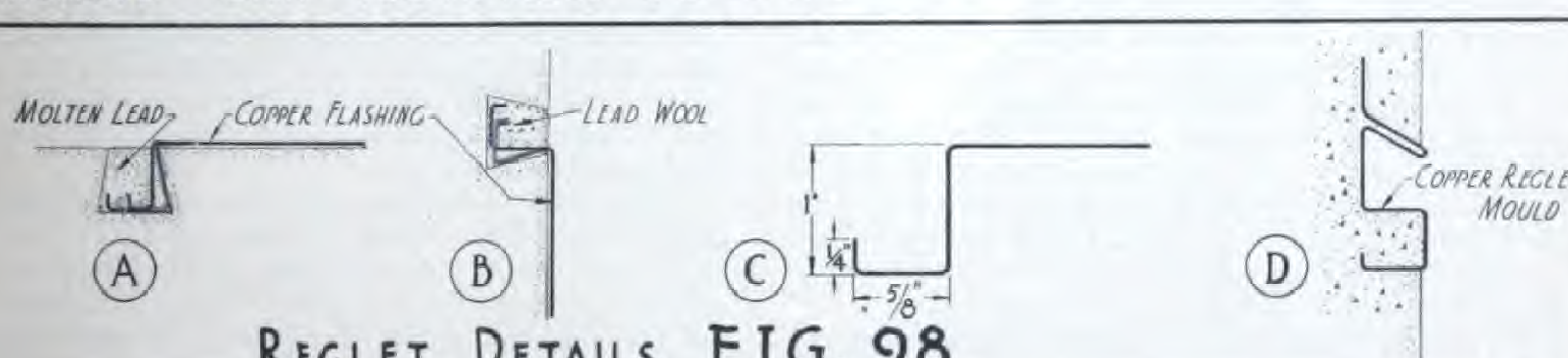
The lead caulking need not be continuous, nor need it be filled in to the very top of the reglet. Efficient design calls for lead plugs at intervals—about 12″ apart—and for filling the intervening space and the top of the reglet with an elastic cement. The use of cement colored like the masonry gives a neat finished appearance.

Large sheets should not be caulked directly into reglets, as movement from temperature changes would tear the sheets. Auxiliary strips should be used in the reglets as cap flashings or to form loose-locks for the flashing or gutter lining. (See Figs. 99 and 100.)

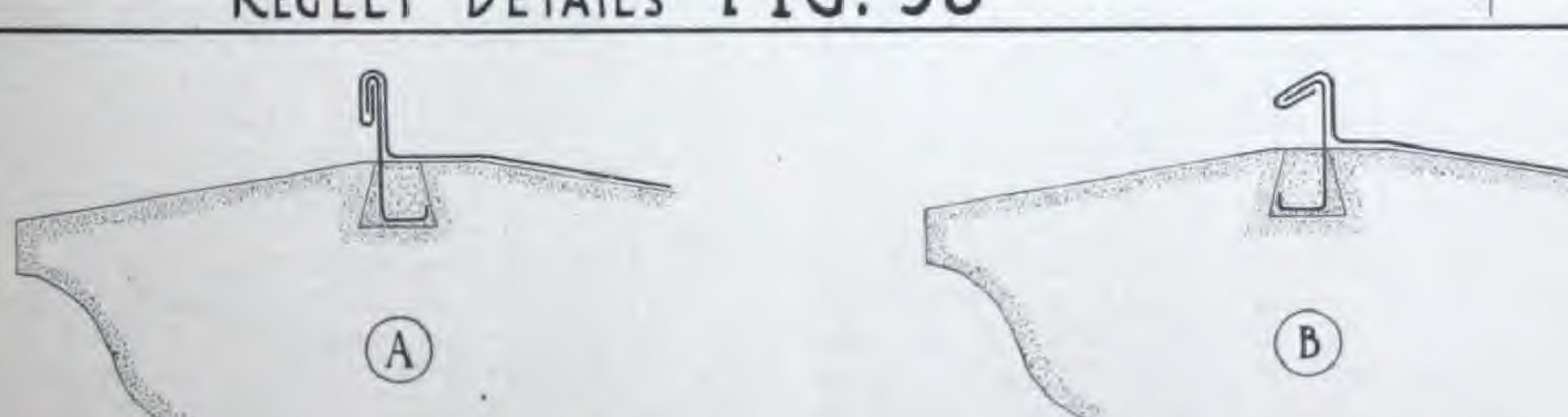
In securing the auxiliary strip in the reglet, it can be inserted as shown either in Figs. 99A or 99B. Some roofers prefer one, some the other. In "A", after the flashing has been locked in place, the reglet filling is protected by the copper sheet. In "B" the reglet filling continues to be exposed and is available for inspection or future attention. In either case the lock between the strip and the flashing should be turned towards the outside, as shown.



FLASHING - SAW - TOOTH ROOF FIG. 97



REGLET DETAILS FIG. 98



LOOSE - LOCK SEAMS AT REGLET FIG. 99

Fig. 100 shows a method of forming a copper gutter lining in a stone or concrete cornice. The flashing is in two pieces, cap and base. The cap flashing is caulked into a reglet or inserted into a masonry joint, and, with the edge turned back on itself ½″ for stiffness, is turned down over the base flashing (gutter lining) to lap at least 4″. The outside edge of the gutter lining is locked to a copper strip secured in a reglet near the outer edge of the cornice. (See Figs. 98 and 99.) The gutter lining is brought around over the stone work and up against the parapet masonry, to be held by the cap flashing. The base flashing should go 3″ above the high-point of the cornice, so if the outlet is clogged the water will spill over the cornice edge.

Midway of the gutter width the two parts of the lining should be joined by a soldered flat-lock seam acting as a stiffener against longitudinal buckling. In wide gutters (2′ or more) this is secured to the sheathing by cleats. The gutter may be graded with neat cement instead of sheathing, but if cement is used and cleating is required, a strip of nailing concrete should be inserted. The outside of the gutter should be sloped somewhat, as shown, to allow free movement, and to prevent gutter ice from displacing the corona stone.

Inside drains generally are used. Cast brass outlets are on the market for this purpose. The connection is to the house drainage-system by cast or wrought-iron pipe with fittings of easy curve. At the gutter lining the joint is made by a special double flange on the outlet. The mass of brass in the outlet is so small compared to that of the heavy iron that galvanic action on the latter is negligible.

Fig. 101 shows formation of a gutter and flashing in a terra-cotta cornice surmounted by a brick parapet-wall faced with terra-cotta. The flashing is carried continuously through the wall beneath the terra-cotta cap to cut off seepage. It is turned down ¼″ at the front, and inside the parapet is locked to the vertical standing seam sheathing with a ½″ loose-lock seam. The standing seam sheathing is lapped 4″ over the main roof copper to a point about 2″ above the roof surface, forming a cap and base flashing. A key is formed in the masonry below the terra-cotta cap. This is done before the flashing is laid, either by setting two bricks on edge or with concrete, exact size and location being determined by design.

The cornice flashing (also the gutter lining) is formed at its outer edge over a terra-cotta roll (1 to 1½″ in diameter formed to receive the flashing), or can be secured as in Fig. 103. The flashing extends back over the masonry, avoiding sharp angles, to the wall. Here it is turned up so the top edge will be at least 3″ above the high-point of the cornice, and is held by a cap flashing. The cap flashing is carried back of the terra-cotta facing of the parapet 3″ to 4″ above the first joint, and extended to the face where it laps the base flashing 4″. For gutters 2′ or more in width a soldered lock seam should be formed longitudinally in the gutter, and for extreme widths should be cleated down. Where cleating is necessary, nailing concrete should be provided.

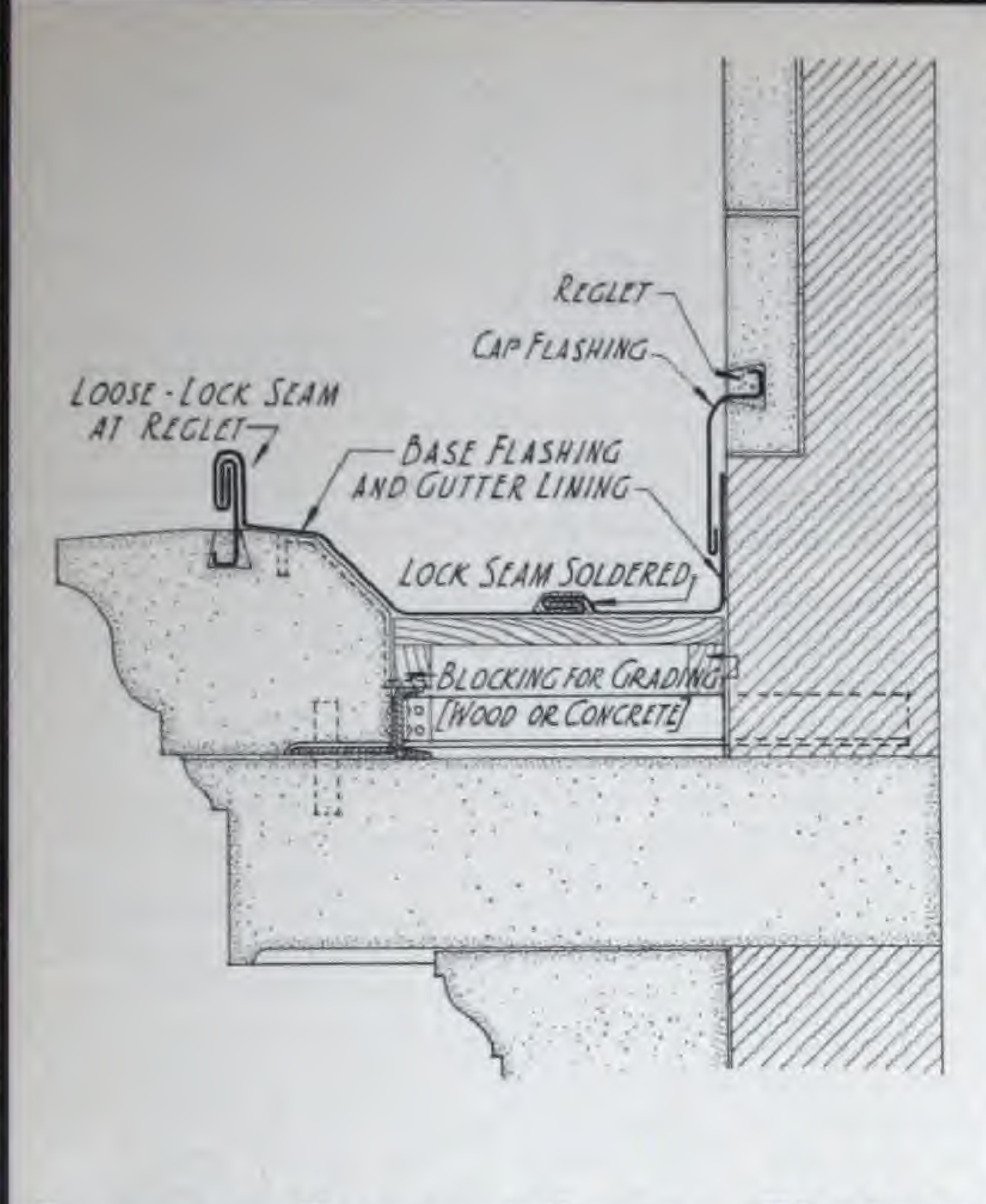
Fig. 102 indicates how the base of a stone balustrade surrounding a balcony or similar projection should be flashed with copper. Balconies of this type usually are of considerable area and the flooring, which also acts as a gutter, should be laid in small sheets (14″ x 20″ or 18″ x 24″) flat-locked and soldered. The grading is done with sheathing or a nailing concrete so the copper sheets can be cleated down. On all sides where reglets are 12″ or more from the flat seams, the copper is turned up back of cap flashings secured in reglets and lapping the base copper at least 4″. If the sheets are 12″ wide or less they can be caulked direct into the reglets. On the outside and at the ends, reglets are cut in the base below the balusters, as shown at the right, and caulked with molten lead. On the inside wall the reglet is vertical and caulked with lead wool. Inside drainage usually is provided, connected to the house system.

In enclosed gutters such as this, scuppers or overflow drains are essential to provide drainage in case of outlet stoppage. It usually is desirable to have the scuppers concealed, but this as well as number and location is a question of architectural design. They should have sufficient capacity, however, to assure prompt drainage if required, and should be placed 3″ below the top edge of the lowest base flashing, to insure against water getting under the flashing. (See Figs. 111 and 112.)

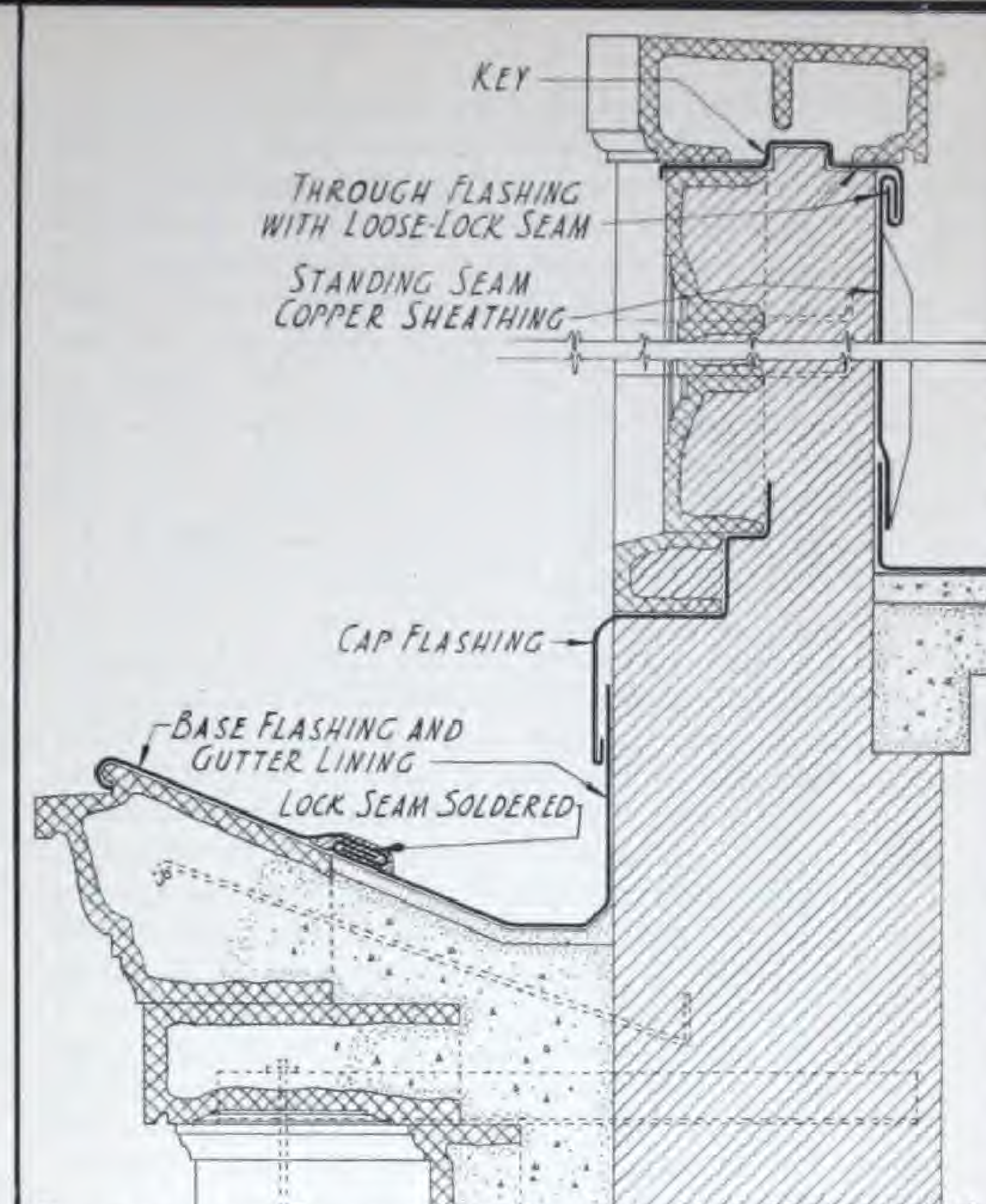
Fig. 103 shows method of flashing a projecting terra-cotta balcony enclosed by a metal rail and with a door or window opening to it. The method of fastening the outer edge of the copper to the terra-cotta is shown in detail in the lower left-hand corner. The design of the terra-cotta, should provide a fillet of at least 1½″ above the top molding. When the terra-cotta is cast, and while still plastic, a row of holes is punched in the face of this step ("A") about ⅜″ in diameter, 1½″ deep, and 8″ or 9″ apart. Before the copper is placed there should be inserted into these holes cylinders of sheet lead of a length about ⅛″ less than the depth of the hole and a diameter the same as the hole. The edge of the copper flashing, containing a row of holes corresponding to the holes in the terra-cotta, then is turned down over the fillet at least 1¼″. A No. 12 round-head brass wood-screw is inserted through the copper and into the lead cylinder. As the screw is driven home it expands the lead cylinder, forming in effect an expansion bolt. It generally is not necessary to solder over the top of the screw heads, but if much water will come over the edge of the step it is good practice to do so.

Being thus secured at the outer edge, the copper is laid over the floor of the balcony, using ½″ soldered lock seams when over 24″ wide, and then turned up against the masonry at least 4″ where it is lapped by the cap flashing. When the flashing is penetrated by upright posts, such as the corner posts of the balcony rail in this instance, the place where such penetration occurs must be protected by some means such as described in Fig. 120. The regular flashing being first completed, then penetrated as required, and the corner post secured to the masonry, the copper cap is formed around the post or slipped over it, soldered to the flashing and filled with waterproofing-compound.

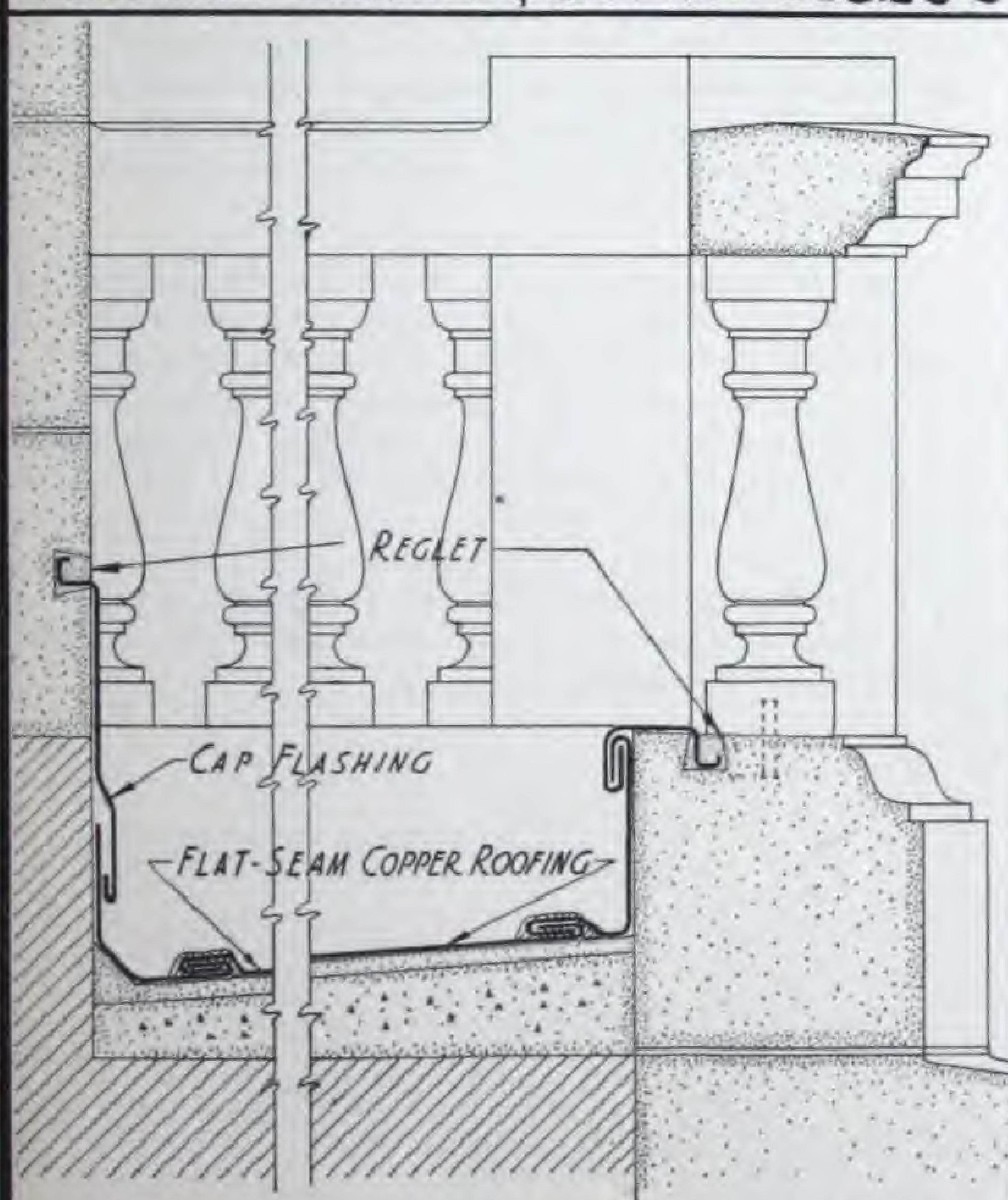
The cap flashing is placed before the terra-cotta sill, the wood sill, or the balcony-floor flashing are in position. It must be wide enough so on completion it will lap the floor flashing 4″, extend through the wall under the terra-cotta sill, and up and under the wood sill. After the cap flashing is in place the terra-cotta sill is placed; then the wood sill. Some prefer the flashing wide enough to extend back of the wood sill, but a water-bar would make this unnecessary. The use of a copper water-bar at the joint between the wood and terra-cotta sills is recommended. A complete description of this and the method of its application may be found in the drawing and description of Fig. 124.



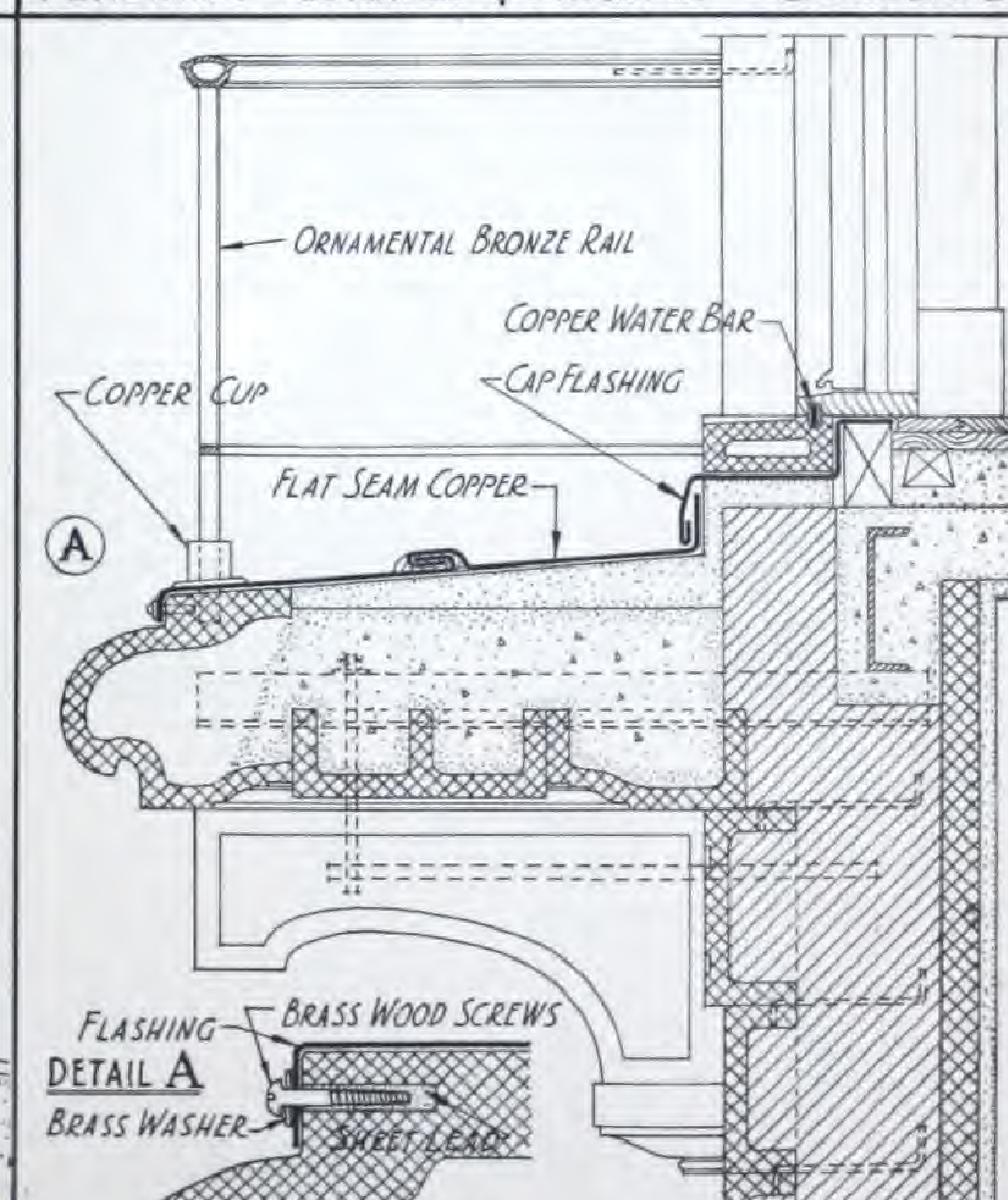
FLASHING - CORNICE & GUTTER FIG.100



FLASHING- CORNICE & PARAPET FIG.101



FLASHING - STONE BALUSTRADE FIG.102



FLASHING - TERRA COTTA BALCONY FIG.103

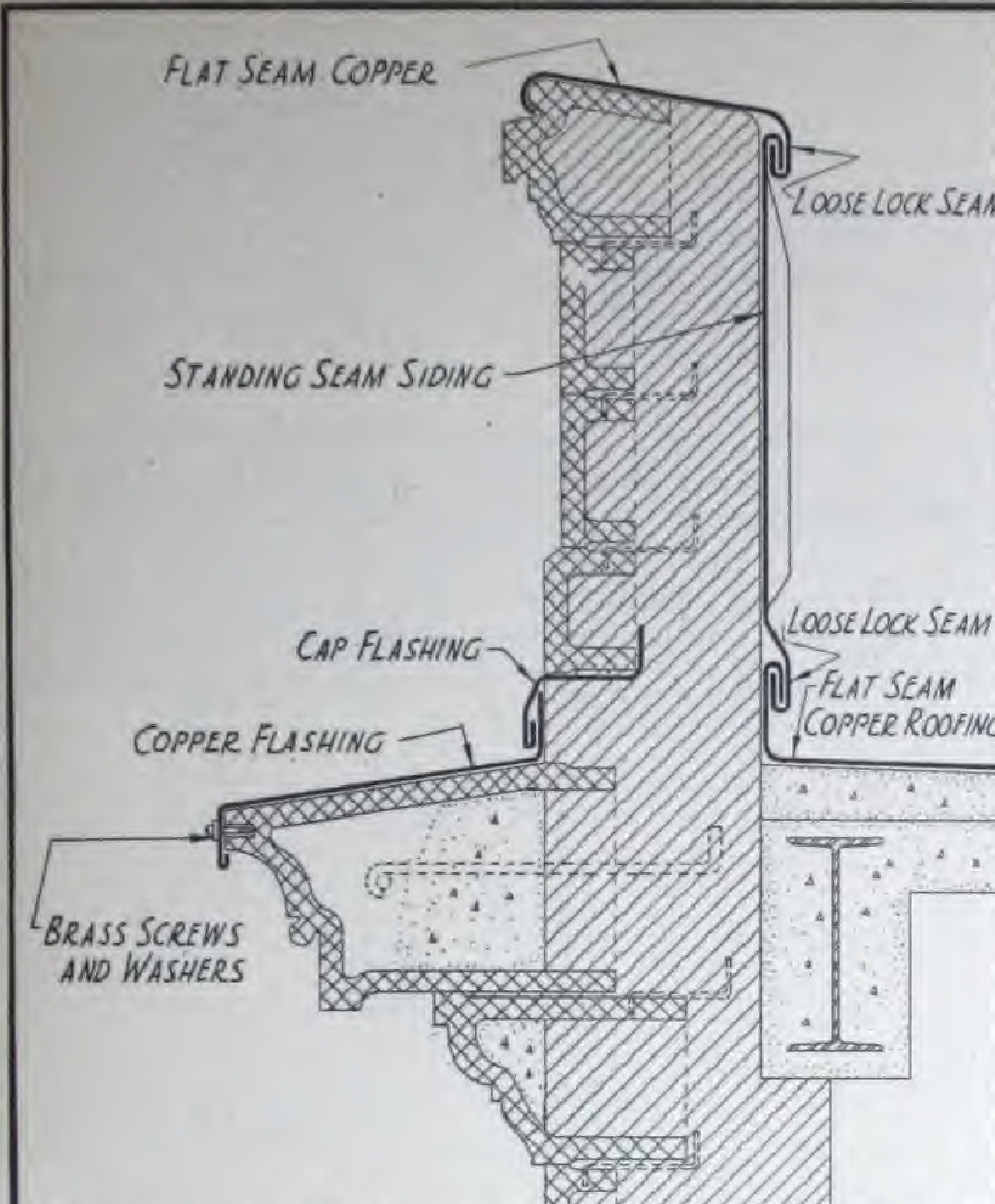
Fig. 104 shows method of flashing a terra-cotta cornice surmounted by a brick parapet wall faced with terra-cotta. It is important that the entire top and back of the wall be covered with copper since this prevents absorption of moisture through the joints of the terra-cotta and brick. In designing the terra-cotta cap the upper part should be made with a roll, as indicated, from 1″ to 1½″ in diameter. The copper is formed over this and extended over the top of the cap and down on the inside of the parapet wall, where it is connected to the copper roof by a loose-lock seam 6″ to 8″ above the deck. The copper at the back of the parapet should be formed with standing seams and the top with flat seams soldered. The two are joined by a loose-lock seam. The top of the terra-cotta cornice also should be covered with copper to protect the joints. The copper may be formed over the outer edge of the cornice as shown, or the cornice may be designed as at "A" in Fig. 103 and the copper formed over this fillet. In either case it is secured by screws as described in Fig. 103. After securing the outer edge of the copper the metal is brought over the top of the cornice and turned up on the masonry where it is held by a cap flashing. For cornices with 2′ or more projection it will be found expedient to form a soldered lock seam half way across the projection and lengthwise of the cornice, or to use small (14″ x 20″) sheets flat-locked and soldered. The cap flashing is turned up 3″ or more between the terra-cotta and the brick work.

Fig. 105 presents the method of flashing a terra-cotta cornice below a balustrade. The cap flashing on the outside of the balustrade, and the flashing above it extending through the wall, both are built in as the masonry progresses. Before laying the upper flashing a key is formed, as described in Fig. 101, to avoid chance of a side slip in the balustrade after erection. The copper flashing should be formed closely over the projection, in one piece and wide enough to extend entirely through the wall and be turned down on the inside far enough to lap the base flashing at least 4″, and also turned down outside about ½″ over the terra-cotta to form a drip. The lower cap flashing, also built in with the masonry, turns up against the brick work back of the terra-cotta at least 3″ and down outside on the face of the wall far enough to lap the cornice flashing at least 4″. The outer edge of the terra-cotta cornice should be designed to provide a fastening for the outer edge of the copper base flashing covering the top of the cornice. (See Fig. 103.) For cornices 2′ or more in width a soldered lock seam should be formed halfway across the projection and lengthwise of the cornice, or the covering should be made up of small sheets applied with flat seams.

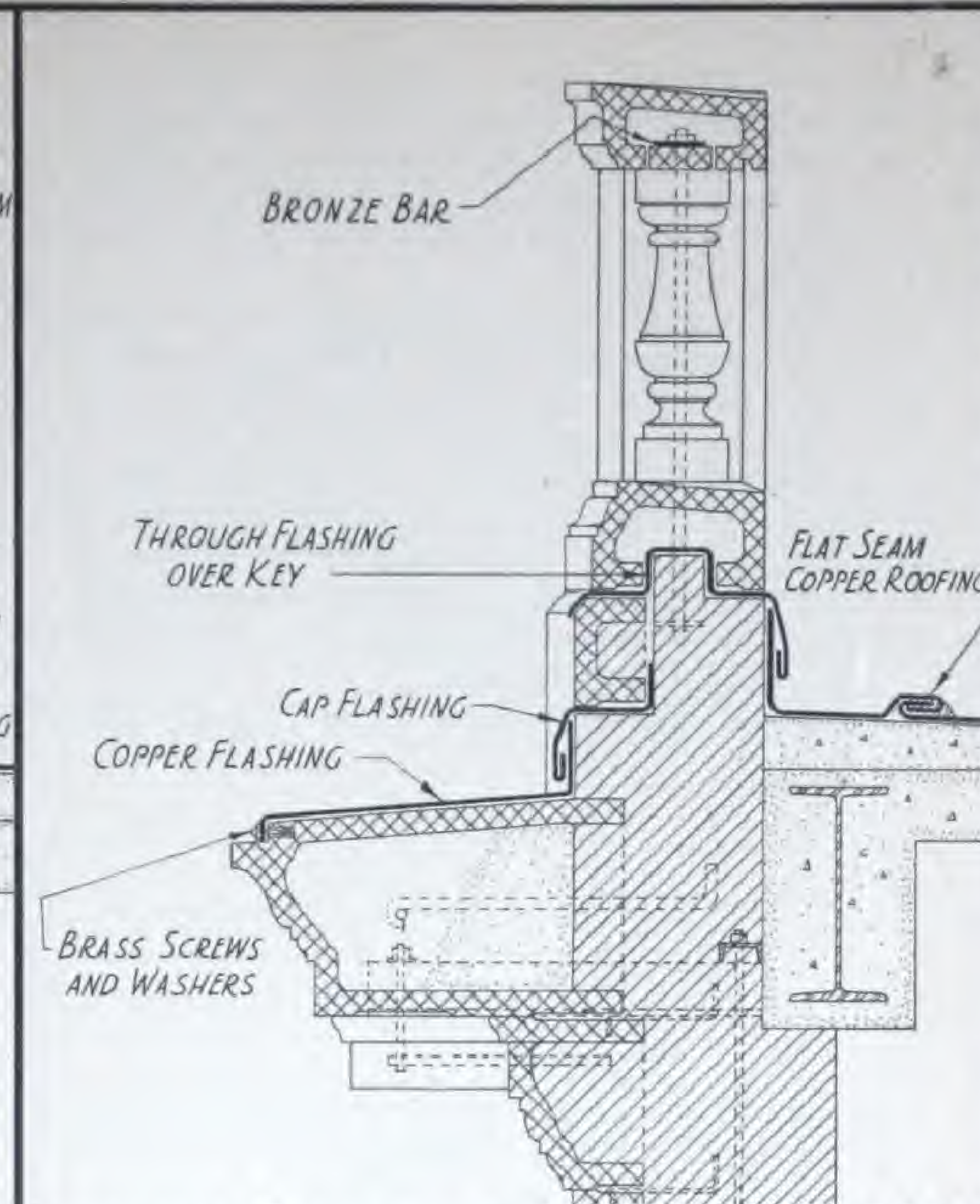
A ⅜″ thick bronze bar should be set in the top rail of the balustrade. This bar is continuous on top of the balusters, and, if possible, should be returned at the ends of the balustrade into the main wall of the building and anchored. The bar is placed on top of the balustrade dowels before the terra-cotta rail is set.

Fig. 106 shows the method of flashing a balcony of terra-cotta having a rail of the same material and a window or door opening onto it. The copper is laid from the outside of the cornice over a masonry key (see Fig. 101), and across the floor of the balcony to the main walls, where it is turned up against the masonry and under the terra-cotta and wood sills and up back of the wood sill. On the outside the copper is secured by screws, as in Fig. 103, or over a roll in the terra-cotta as in Fig. 101. The introduction of one or more soldered lock seams or the use of small sheets flat-locked and soldered will be necessary on the floor of the balcony, depending on the width. Some provision must be made for copper-lined scuppers at such places and of such size as the design of the rail will permit. The main drainage system will depend upon individual considerations; but scuppers or auxiliary drains of sufficient capacity to handle drainage should supplement the regular system in case outlets become clogged. The scuppers are placed so the flashing of the balcony floor rises 2″ or 3″ above them all around. The copper water-bar is described in Fig. 124, and the bronze bar in the balustrade rail in Fig. 105.

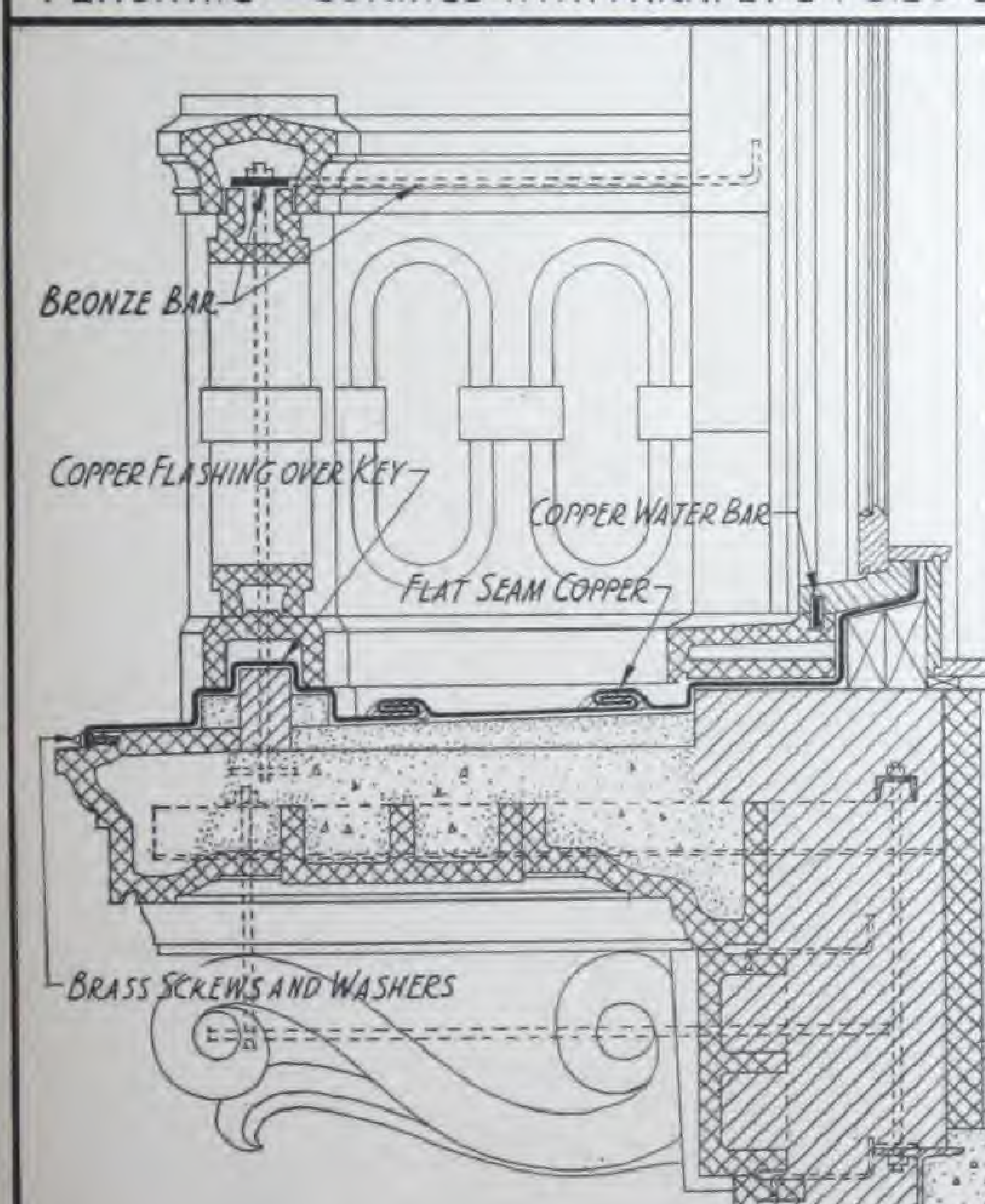
Fig. 107 indicates how a projecting window-cap or cornice of terra-cotta surmounted by a terra-cotta balustrade should be flashed and the rail steadied and secured to the roof. The method of avoiding movement of the rail is by bracing it from the roof with bronze rods. A ⅜″ bronze bar extending the length of the rail is placed on top of the balusters and connected by vertical rods to the steel framing below, and also to a stay rod from the main roof. The points where the ends of these rods are fastened to the main roof must be well flashed. (See Fig. 120.)



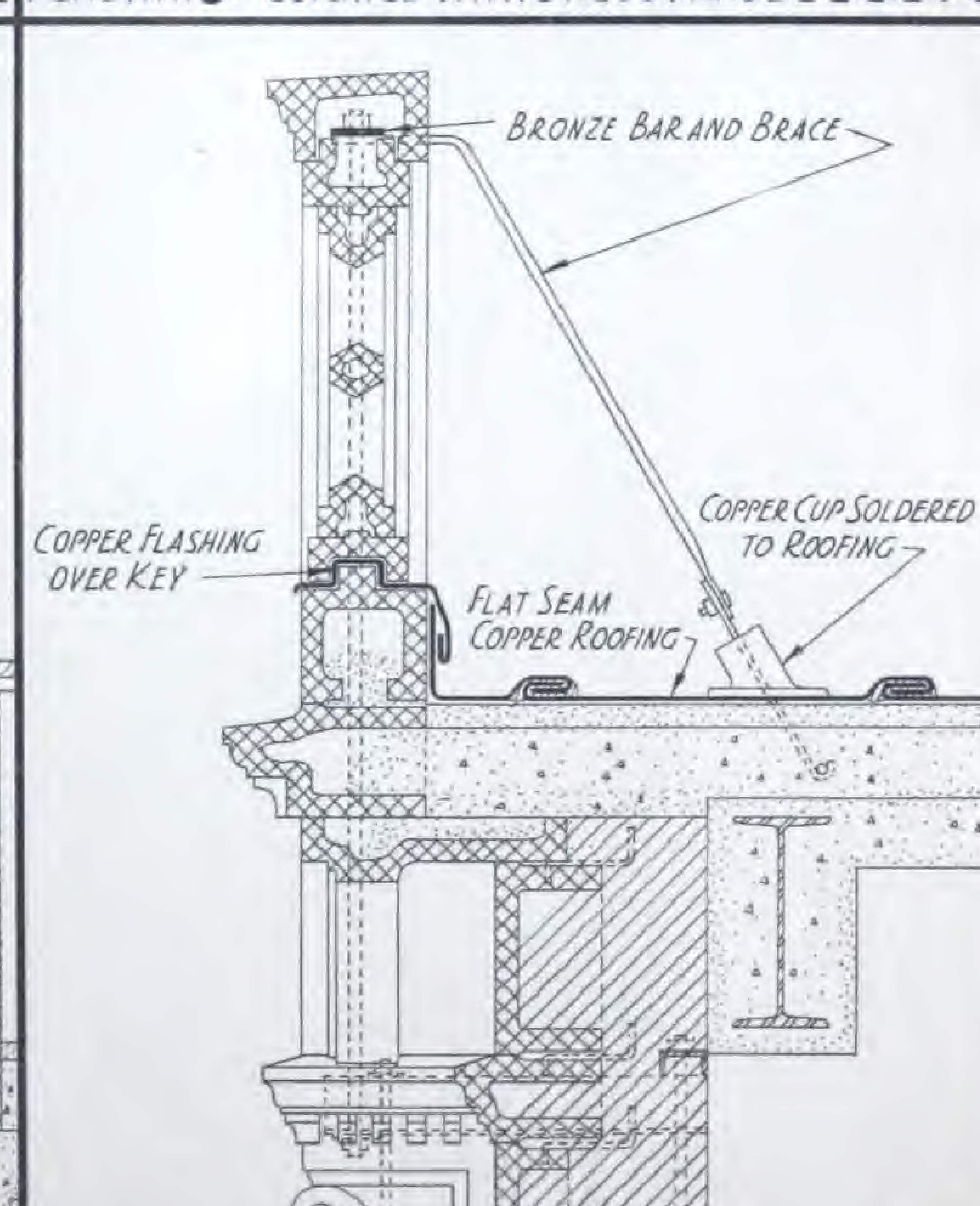
FLASHING - CORNICE WITH PARAPET FIG.104



FLASHING - CORNICE WITH BALUSTRADE FIG.105



FLASHING - TERRA COTTA BALCONY FIG.106



FLASHING - BALUSTRADE ABOVE CORNICE FIG.107

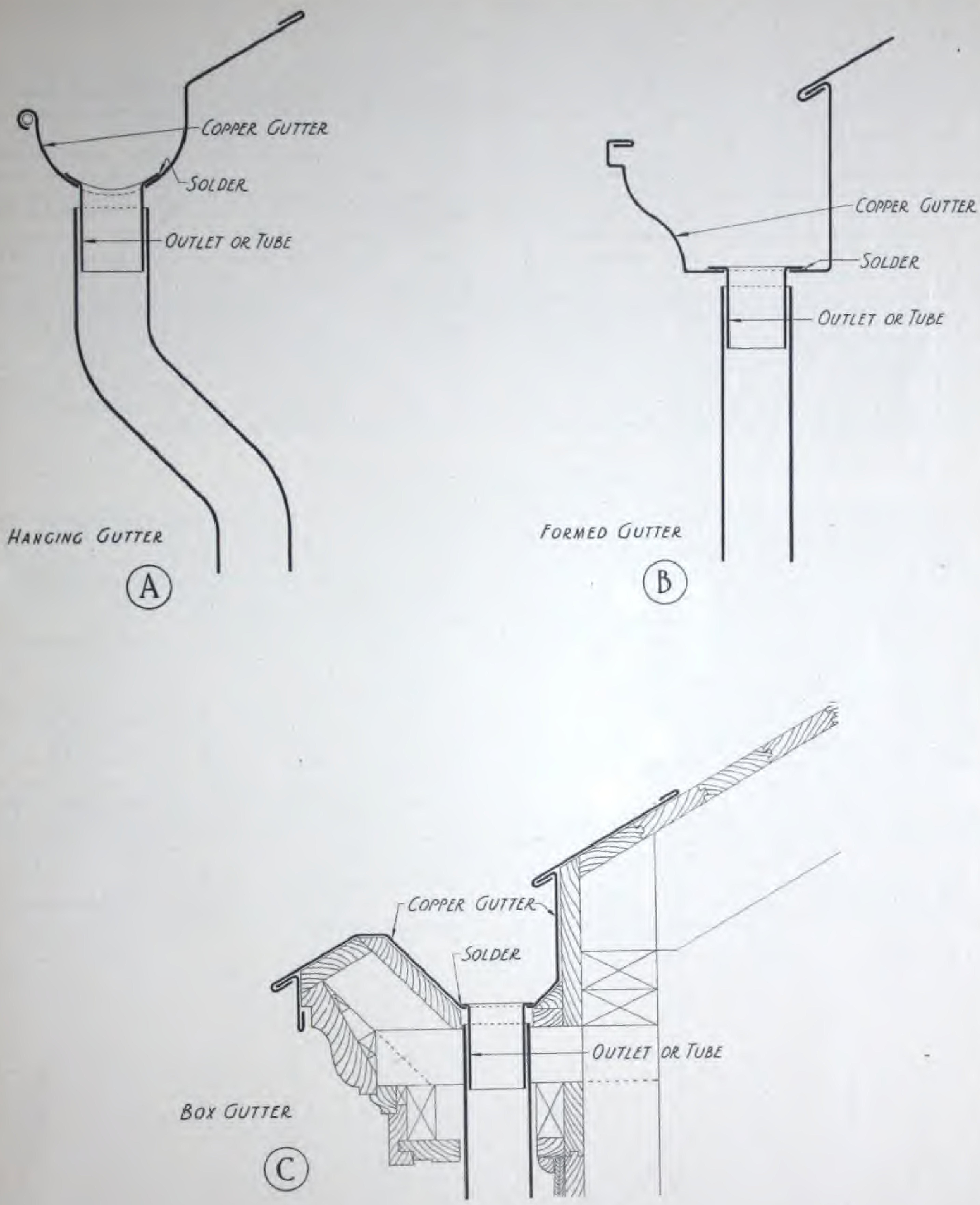
Outlets

Proper outlet installation is of utmost importance. These are the connections between gutters and leaders, and must be designed correctly to accelerate the velocity of the water in its transition from horizontal gutter flow into vertical leader flow. Full data on design will be found beginning on page 97.

The problem would be one of hydraulics alone, were it not for practical considerations. The usual practice is to determine first the size of leader required to carry off the drainage under maximum conditions. An outlet, then, is used which tapers down to this size, but which is larger where it meets the gutter. The entrance to the outlet forms a conical depression in the bottom of the gutter. An elliptical shape at the top of the outlet, with the long diameter in the direction of the gutter length, aids in collecting the flow.

For instance, with a 6″ semi-circular gutter, the outlet should be 6″ in the long dimension but need have a short diameter of only 4″. For semi-circular gutters of other widths, the outlets should be of the same proportions. In rectangular gutters 6″ wide, or less, the outlet should be about 2″ less in width than the gutter and about the same length as the gutter width. In all cases the outlets can be tapered down to the size of the leader.

Fig. 108 presents methods of installing outlets for hanging, formed, and built-in gutters. The outlets or tubes have flanges at the top all around, which lie on the bottom of the gutter, and are securely soldered to the gutter. The leader, or conductor, then, slips over the outside of the other end of the outlet, lapping at least 2″ to form a slip joint with sufficient clearance to permit movement of the gutter.



OUTLETS FIG. 108

Fig. 109 shows methods of making a water-tight connection between two kinds of roofing and an inside iron pipe or leader. The one on the right is a method of connecting to a felt-and-gravel or other composition roof. The one on the left is a method of connecting to a sheet-copper roof. After the drain pan and the drain pipe have been definitely located, a short copper tube is fitted to make the connection between them. At the top this tube is flanged 1″ and soldered to the pan when the assembly is made. The lower end is fitted to a brass ferrule which has a rounded shoulder at the bottom, over which the tube is flanged and curled. The tube is then set into the C. I. pipe and caulked with lead by the plumber. (For detail see Fig. 112.) For the composition roof the copper should extend onto the roof 4″ beyond the gravel-stop and be incorporated with the roofing. For sheet-copper roofing the connection between roofing and flashing is by a lock seam secured to the roof by cleats. This seam is turned in the direction of the flow and soldered. The drawing shows one sheet from the gravel-stop and seam to the bottom of the tube, but the pan is built up of several pieces. Number and arrangement vary with design.

Fig. 110 shows another method of connecting a roof surface to an inside leader. The right-hand side shows a composition roof on a wood base and the left-hand side a tile roof on a concrete base. The copper tube, before being placed in the cast-iron pipe, is coated heavily with asphaltum. The tube should be secured to the flashing flange on the roof by a soldered lap seam, as indicated.

The flange should extend on the roof a distance of at least 4″ beyond the crimps and be incorporated with the roofing. Near the outside edge of the flashing flange a crimp is tack-soldered. In the right-hand example it should be high enough to retain the gravel or slag, and on the left-hand side it should be high enough to finish flush with the top of the tile. The junction of the copper tube and the iron pipe should be caulked carefully by the plumber, and the opening at the top of the tube provided with a strainer.

Scuppers and Auxiliary Drains

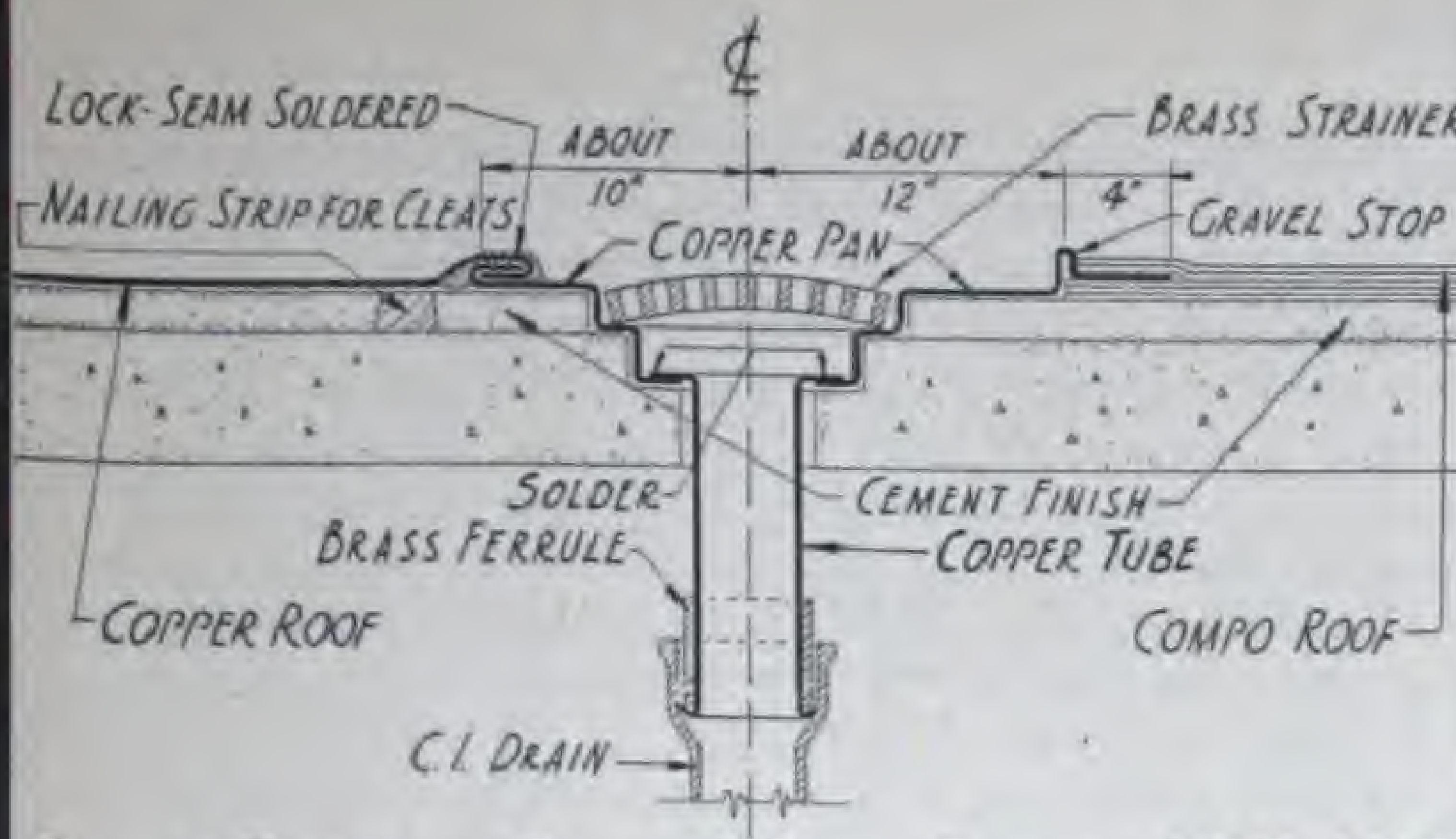
One important point of roof drainage design often is forgotten—the proper provision for overflow by means of scuppers. Usually they are holes or slots through enclosing walls or balustrades, or they may be auxiliary outlets connected to the drainage system.

Many buildings have flat roofs enclosed by parapet walls and with inside drains. When the outlet becomes clogged water collects on the roof, not only causing overload, but working its way over flashings and into the building. Where there is not ample provision for escape of the water when the leaders do not work it is essential that scuppers or overflow drains be provided. These should preclude possibility of clogging and should be unobstructed by screens, etc.

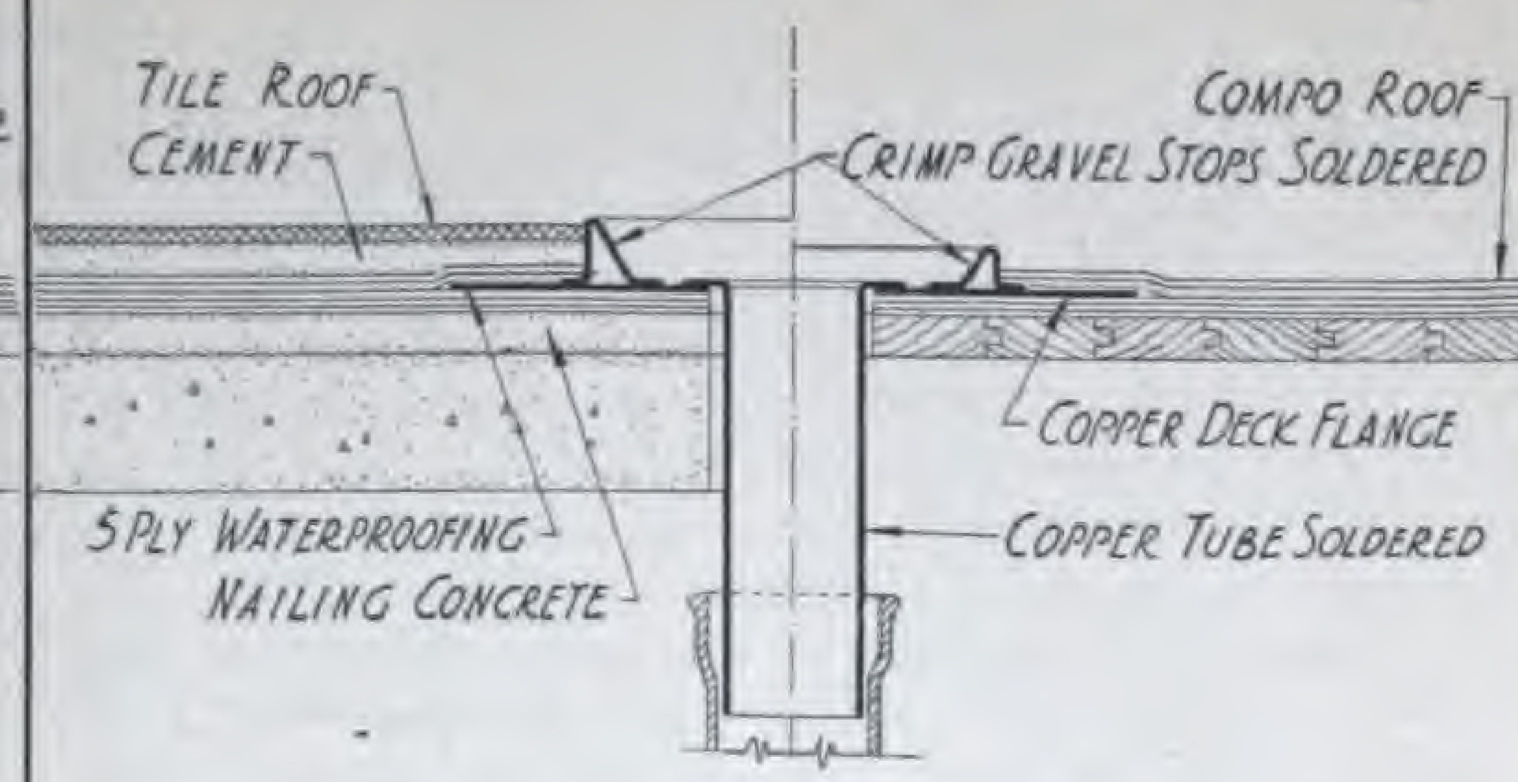
Fig. 111 shows a section through a scupper. It should be placed so that the top is at least 3″ below the top of the lowest base flashing. Pipes sometimes are inserted in the scuppers, projecting 1″ or 2″ beyond the wall to form drips away from the building face. It also is possible, and often architecturally desirable, if provision is made when the walls are erected, to have drains for the scuppers inside the walls. When copper flashings are used the scuppers are completely lined with copper, this being soldered to the base flashing, and the counter flashing worked around the hole, or omitted at these openings.

Scuppers also must be used to drain all balconies or similar small areas enclosed by a balustrade or wall.

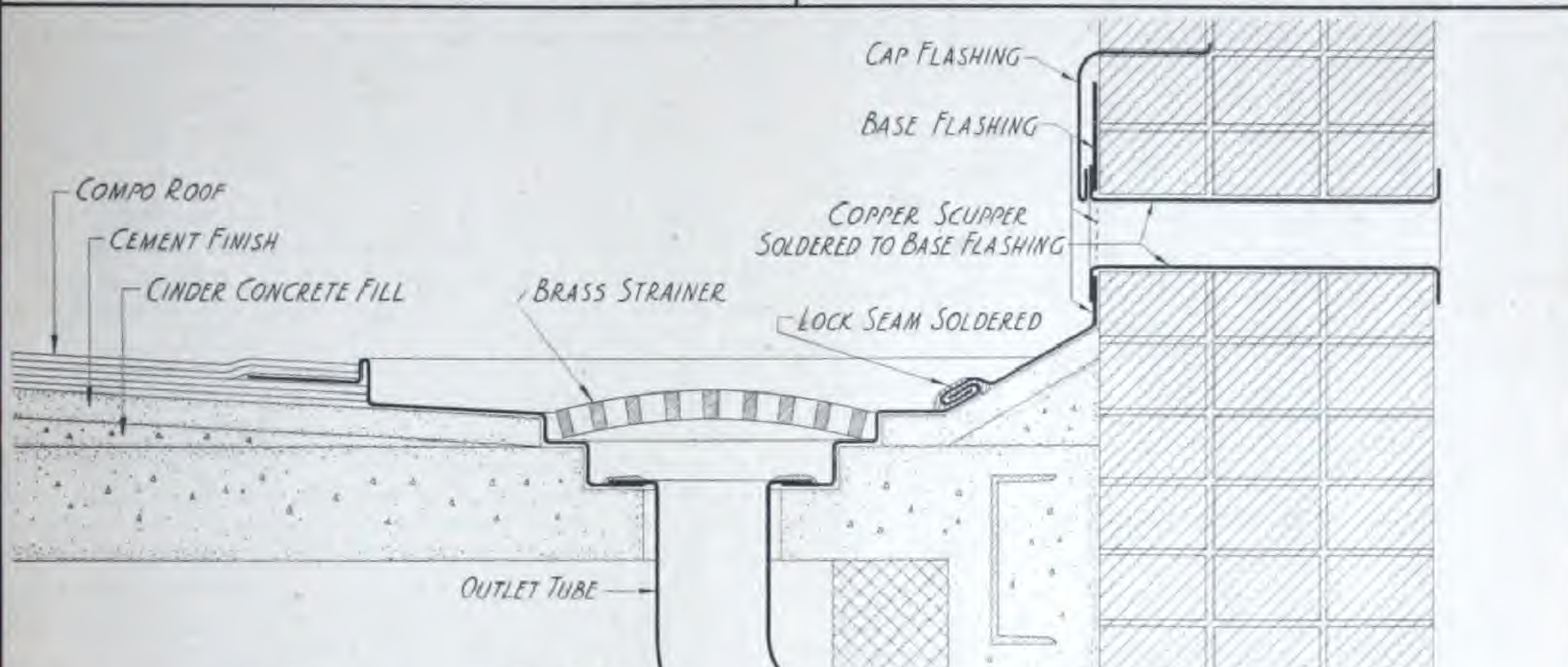
Fig. 112 shows another method of providing auxiliary drainage. It consists of a second outlet beside each main outlet, which is carried up above the bottom of the gutter. This secondary outlet may be drained separately or can be attached to the main drain with a Y-branch. This method has the advantage of avoiding water pouring from the building walls, but can be used only if there is at least 6″ vertical distance between the main outlets and the top edge of the base flashings. To avoid being clogged with the main outlet, the auxiliary branch must be carried at least 3″ above the gutter bottom, also being 3″ below the tops of all base flashings.



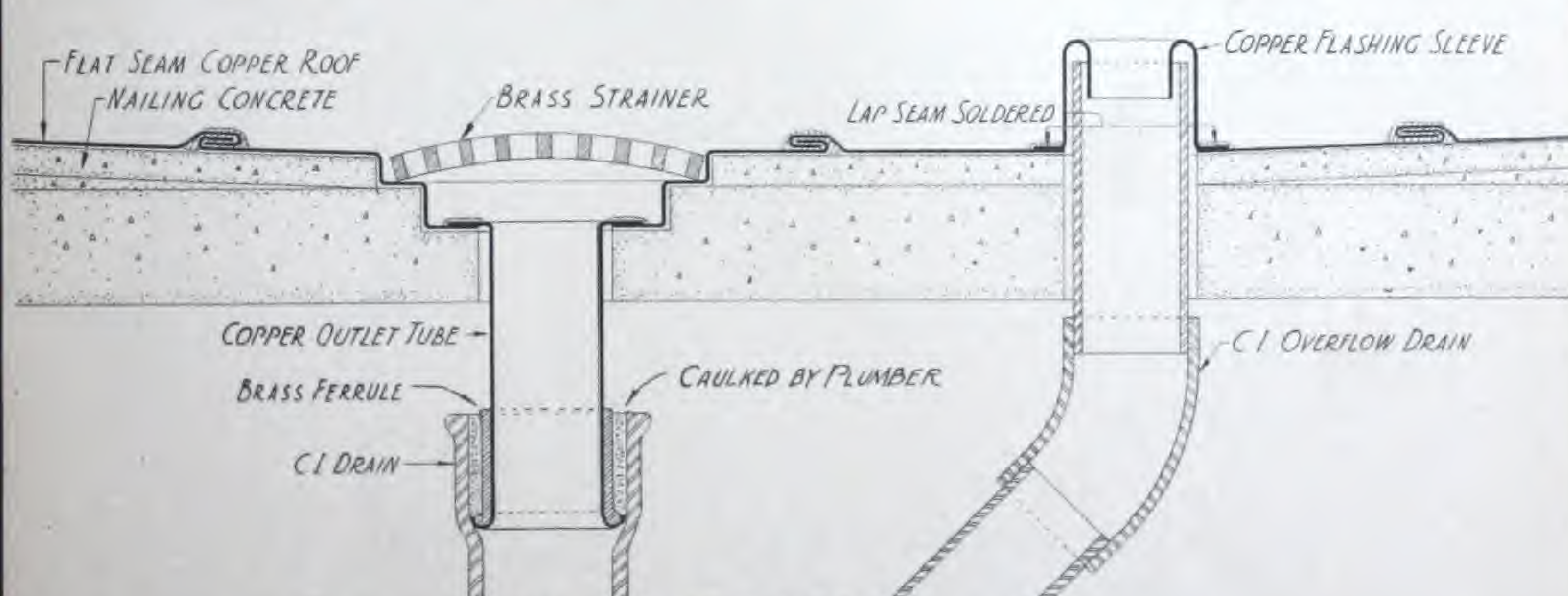
OUTLET FLASHING- COPPER & COMPO ROOFS FIG.109



OUTLET FLASHING- TILE & COMPO ROOFS FIG.110



OUTLET WITH SCUPPER FIG. 111



OUTLET WITH OVERFLOW DRAIN FIG. 112

FLASHINGS OF STRUCTURAL PARTS PASSING THROUGH ROOF

Chimneys

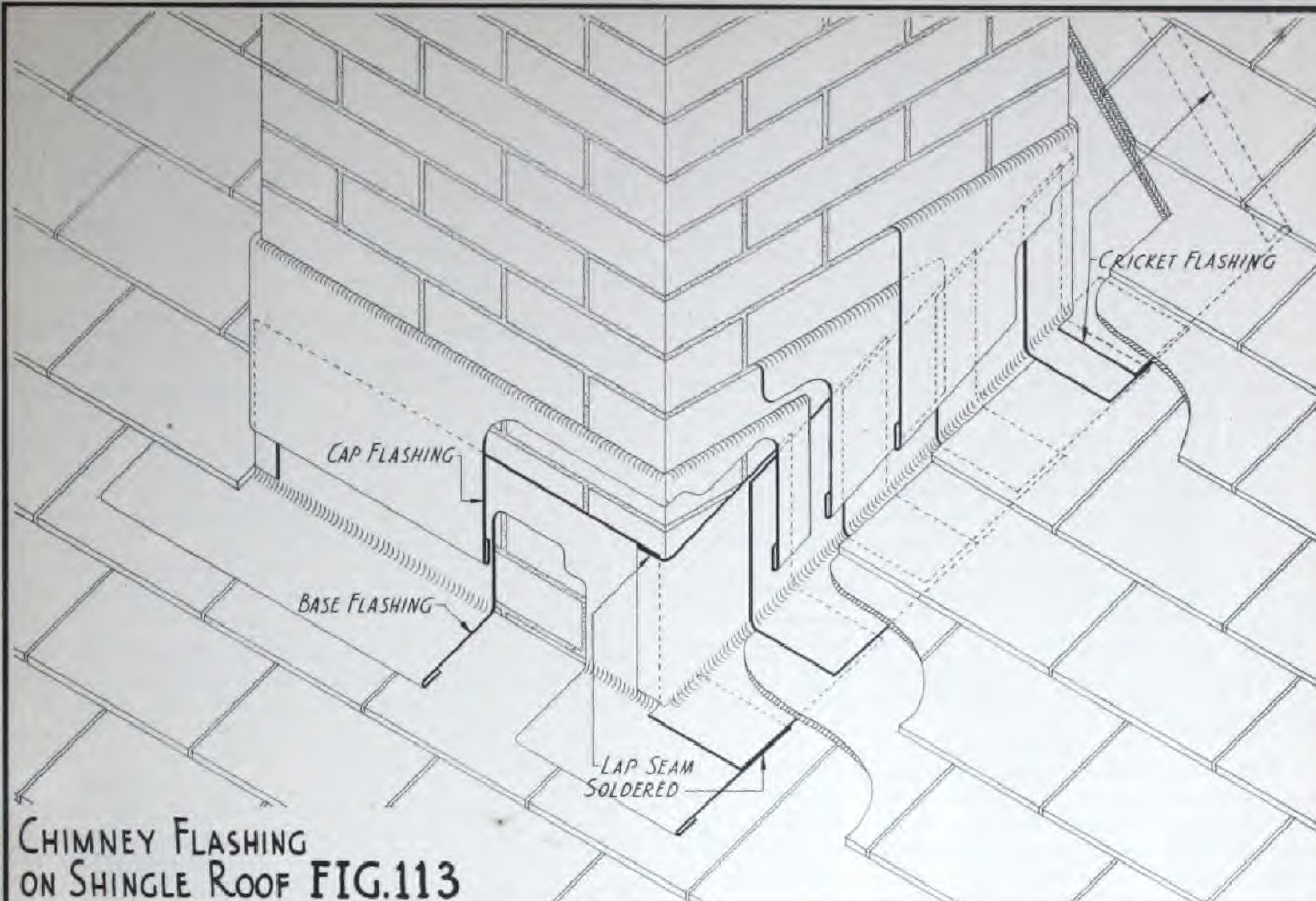
Fig. 113 shows method of flashing a chimney on the slope of a shingle, slate, or flat tile roof. The roofing is laid until the course is in place over which the flashing at the lower end of the chimney is to rest. This base flashing then is set, extending out on the shingles 4″ to 6″ with bottom edge turned back on itself ½″ for stiffness, and it is carried up the chimney so the cap flashing will lap at least 4″ over the base flashing. The copper sheet is long enough to extend beyond the sides of the chimney on the roof as shown and allow the next course of slates to lap it 4″. The lowest shingle flashing on each side folds around the corner of the chimney and is soldered to the base flashing. Separate shingle flashings, serving as base flashings up the sides, are inserted with each course of shingles, and are hooked over the top edge of the shingles. Each shingle flashing should lap the one below at least 3″, and the shingles should lap over the copper 4″ at the sides.

The base and shingle flashings are cap flashed as shown. Along the lower side where the cap flashing is horizontal, it is continuous, but up the sides it is made of separate pieces and stepped as required by the slope of the roof. The separate sheets should have side laps of at least 3″ and lap the base flashings everywhere at least 4″. The cap flashings are best inserted as the chimney is constructed, carried all the way through to the inside, and turned up 1″ against the flue linings. If this is not possible, the mason can leave sand courses at points the flashings will come. These are easily removed, and the flashings inserted to a depth of at least 2″ into the brickwork and fastened by lead plugs 1″ wide and 8″ apart. The joints are finished with roofing cement.

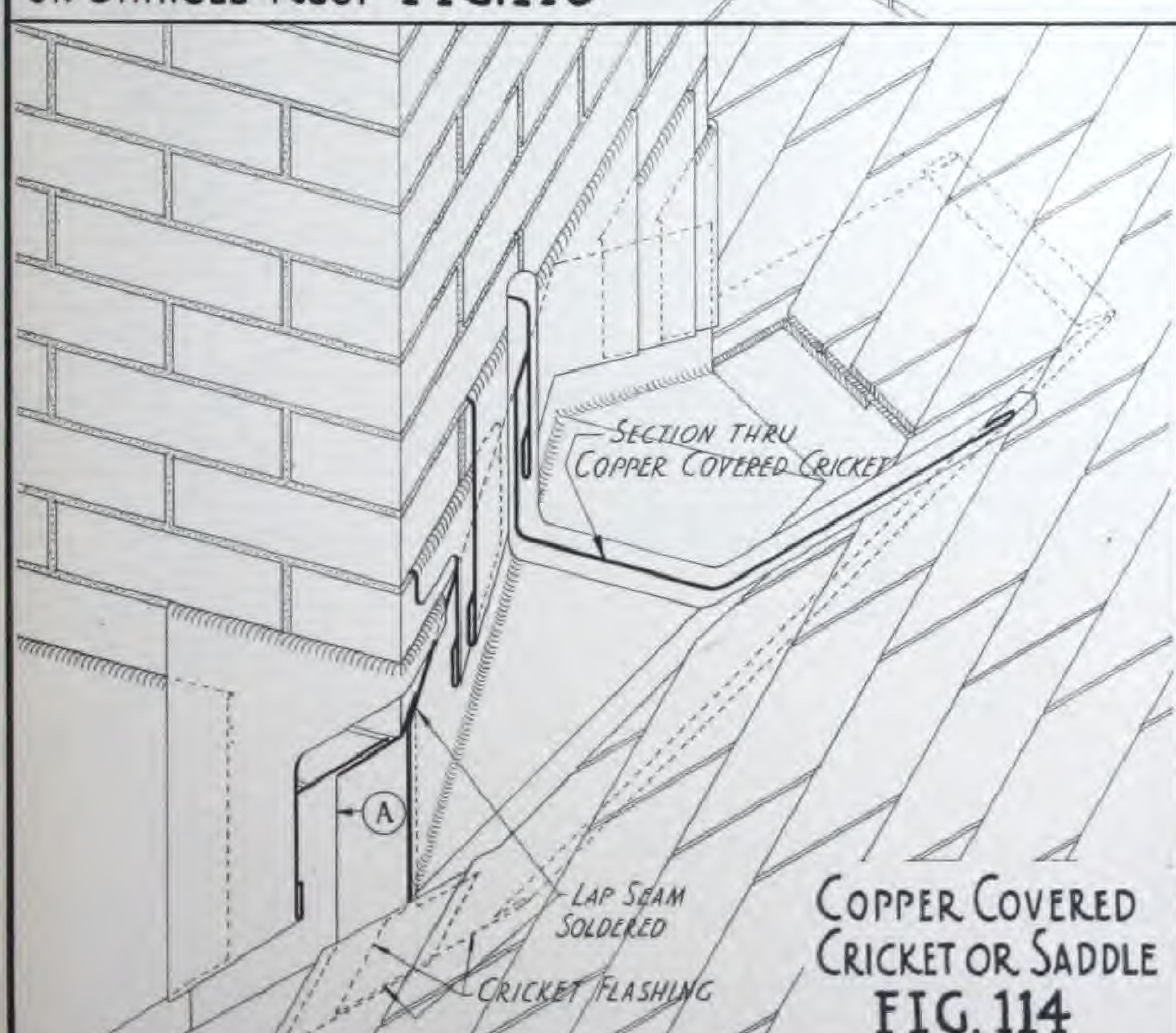
Fig. 114 shows cricket or saddle such as should be formed back of all chimneys on the slopes of roofs, in order to shed water to either side and eliminate a pocket for collecting snow. This generally is formed of wood, with steeper slopes in climates having considerable snow, and is covered with copper. Against the chimney the metal is turned up as a base flashing and cap flashed with a lap of at least 4″ all along. The cap flashings are stepped as required by the slope of the saddle. The saddle flashing is carried up under the shingles at least 6″, with top edge folded back to prevent water getting under the roofing. At the corners a base and shingle flashing is inserted as at "A" over which the saddle flashing is lapped and soldered, both on the slope and against the chimney, and then cap-flashed.

When chimney is at the ridge, no saddle, of course, is required. Each half of the chimney is flashed in the same manner as the lower part in Fig. 113. Sometimes in such cases the base flashing is formed of strips at the sides and ends, as at the bottom of the chimney in Fig. 113. Small sheets interwoven with the shingles are better, however, for large chimneys.

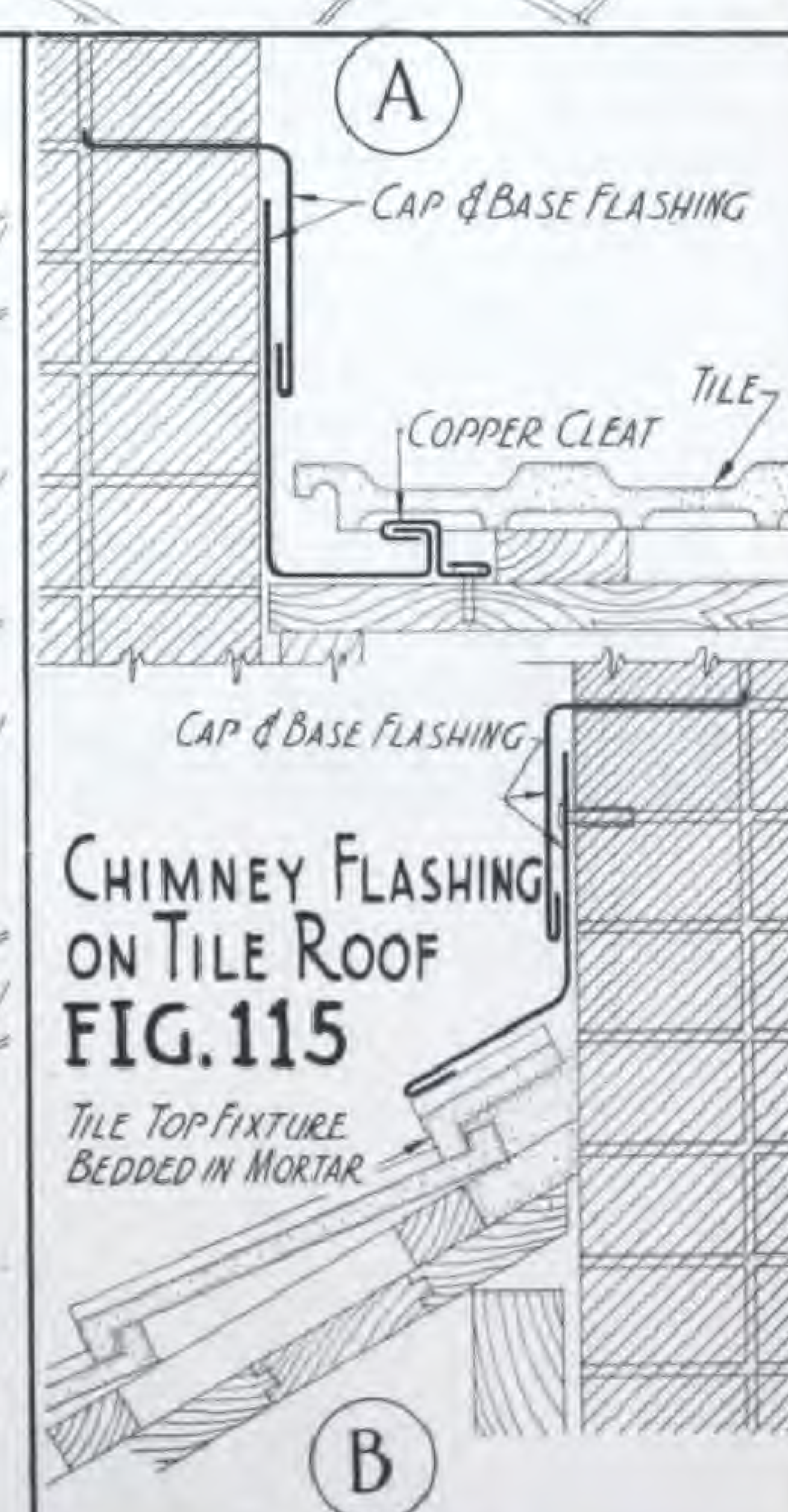
Fig. 115 indicates the method for flashing a tile roof against a brick wall or chimney, Detail A showing the method when the side of the tile roof adjoins the brickwork, and Detail B that when the brickwork is at the top of the tile roof. The cap flashing should be turned on itself ½″ for stiffness. It is built-in and stepped in the usual manner for cap flashing in brickwork. Attention is called to the method of terminating the base flashing which, in the case of the side wall, should be carried under the first section of tile and cleated. In the case of the front wall the flashing should be carried down on the roof at least 4″ over the tile top-fixture. Cap flashings should lap the base flashings at least 4″, and be stepped if required by the slope of the roof, and also lap adjoining sheets 3″.



CHIMNEY FLASHING ON SHINGLE ROOF FIG.113



COPPER COVERED CRICKET OR SADDLE FIG. 114



CHIMNEY FLASHING ON TILE ROOF FIG. 115

Fig. 116 shows method of flashing an iron vent pipe passing through a shingle roof, and of finishing the pipe with a copper cap. The lower edge of the flashing laps over the shingles not less than 4″, but the sides and top are placed under the shingles and covered about 6″. The edges of the flashing at the sides are folded over ½″ to prevent water driving under the shingles. If the flashing is 12″ or more in width the lower edge should be turned back on itself ½″ to stiffen the metal. The flashing around the pipe should be flared at bottom and soldered to the roof sheet. It should extend to the top of the pipe and be secured by a copper cap. This cap should be 6″ high and project into the pipe at least 2″. The vertical flashing should be carried high enough so the cap will lap at least 4″. The base flashing is carried up above the butts of the second shingle course above the pipe and nailed. The top edge is folded back to prevent water getting under the roofing. The mass of pipe is large compared with the copper, so galvanic action on the iron will be small; yet it is good practice to coat the pipe with asphaltum or wrap it with felt.

Fig. 116A shows the construction with built-up roofing. The horizontal flashing should extend on the roof 6″ in all directions, and be covered with two layers of roofing felt.

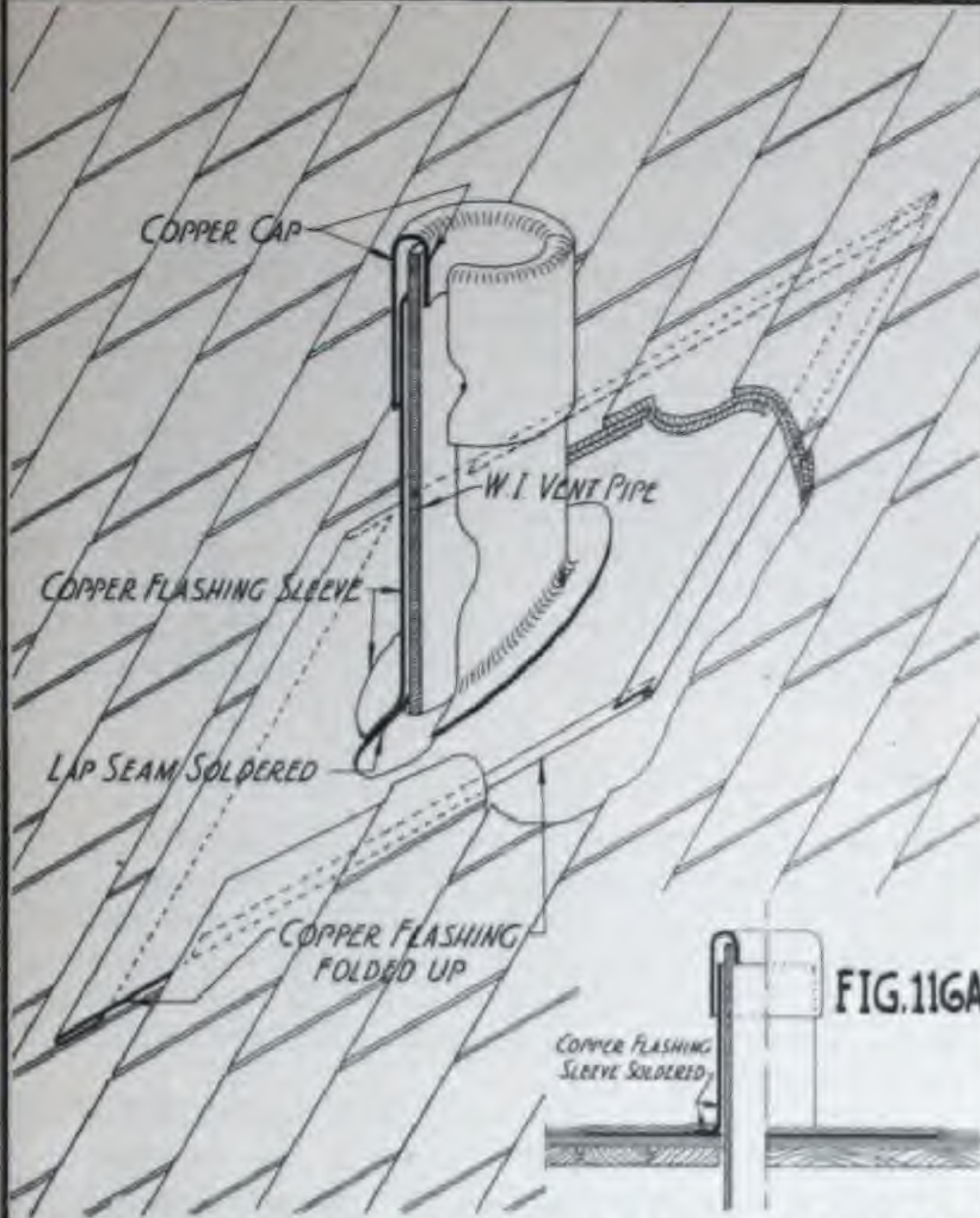
Fig. 117 indicates the flashing of a wrought iron vent pipe through a standing seam copper roof. Here the flashing is finished with a threaded wrought iron cap. The flashing around the pipe is flared at the bottom to lap over and be soldered to the roofing sheet, and is carried up the pipe so the threaded cap will lap it at least 3″. On steep slopes where it may be difficult to solder close to the upper side of the pipe, the flared flashing can be soldered first to an auxiliary sheet in the shop, and this assembly then dropped over the pipe and soldered to the roofing with lap or lock seams on the job. Before placing the cap the threads are coated with white lead. This method is interchangeable with the copper cap in Fig. 116, except in the latter the pipe is not threaded.

Fig. 117A presents the construction when the roof covering is tile. The particular tile or tiles which the pipe penetrates must be bedded carefully in cement mortar as the mechanical bond between this tile and its neighbors probably will be broken by the pipe. The copper flashing should be carried down to the edge of the tile just below the pipe, and be folded back on itself. Above the pipe, the flashing is carried up under one complete tile as far as the wooden nailing strip to which it is fastened with copper nails. On the sides the flashing should be wide enough to be secured under the tile as in Fig. 115A.

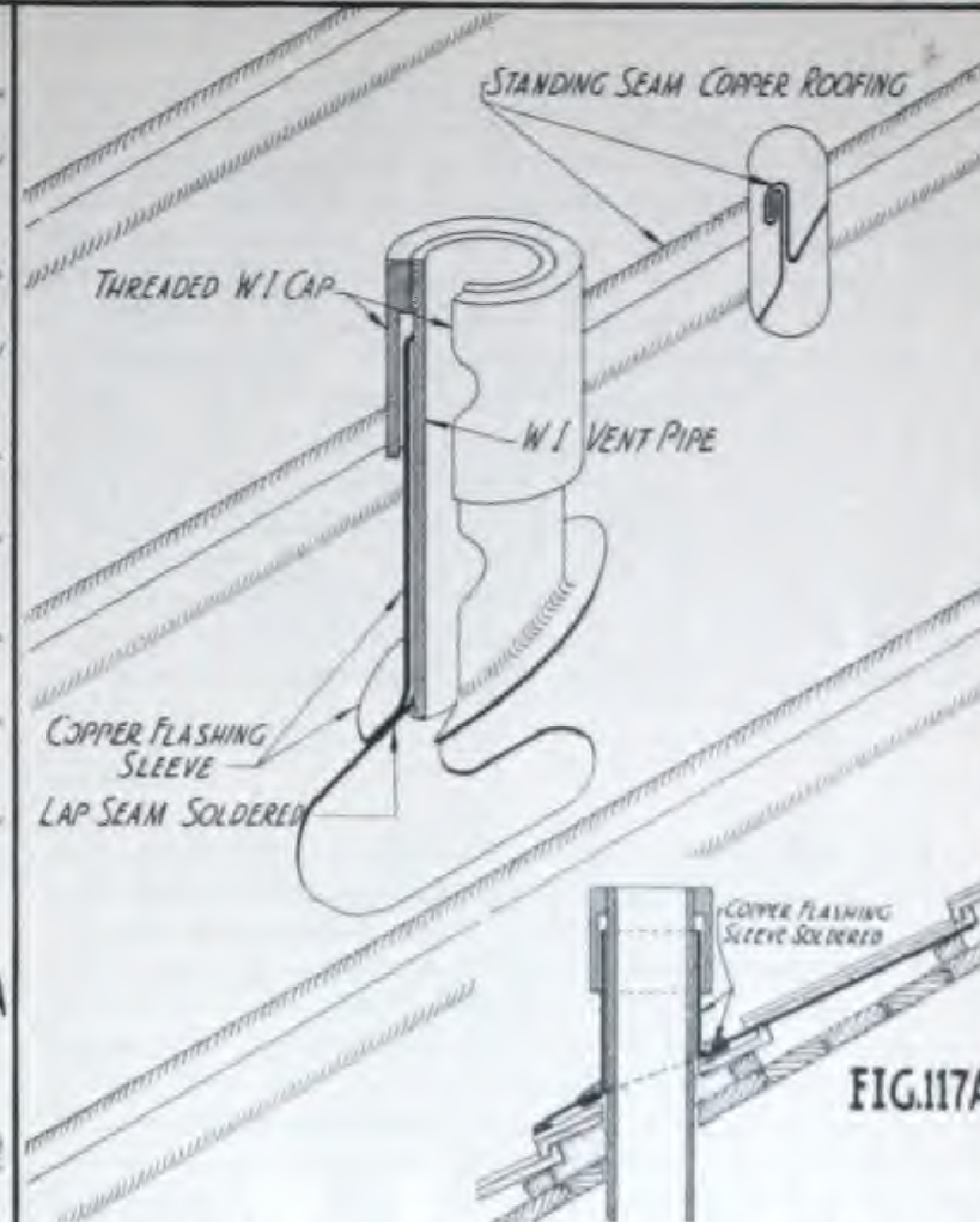
While not required for heavy pipes, it is good practice to insulate the iron from the copper with asphalt paint or wrapped felt.

Fig. 118 shows method of flashing a copper ventilator set on a sloping shingle roof. The ventilator is fastened to the flashing by a soldered lap seam either before or after the ventilator is placed. When on the roof the flashing should lap the shingles at the bottom from 6″ to 8″. At sides the shingles lap the copper at least 6″ and at the top the copper should be carried on the roof far enough so the upper part of the sheet is covered by two thicknesses of shingles. The bottom edge of the flashing is folded under for stiffness and the top edge and sides folded over for a water stop. The flashing is fastened to the roof sheathing by long brass woodscrews. To avoid breaking the shingles the holes for these should be drilled (not punched), and the screws set through slotted brass washers. Only four screws are shown in the illustration, but if the ventilator is large more will be required. They should be spaced not more than 12″ apart. The holes in the flashing should be slotted, to permit movement. The screws, in place, are covered with small copper caps, covering the slotted holes, and soldered to the flashing. See the discussion of Fig. 119 for the matter of "guying".

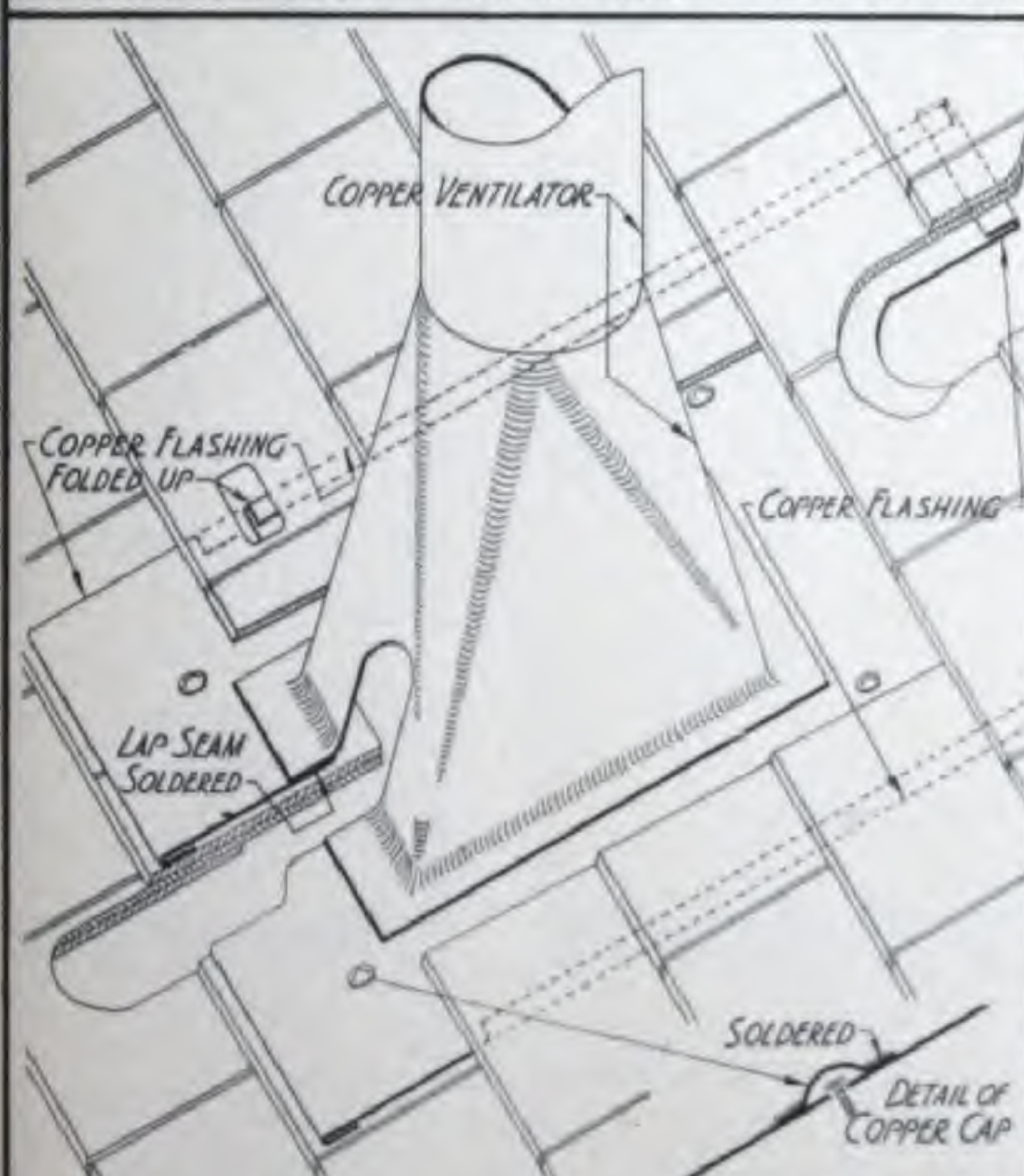
Fig. 119 shows the manner of flashing if the ventilator is placed on the ridge of a roof instead of the slope. The method is similar to that described in Fig. 118, except that the flashing is entirely outside the shingles and is formed over them. If the ventilator is tall it should be steadied by rods or wires fastened near the top by a brass collar and to the roof by brass screw-eyes or similar devices. The flashings for these consist of pieces of copper extending on to the roof about 8″ on each side, and from the butts of the shingles next below up and under the shingles above. The sheet is soldered to the shank of the fastening, or a thimble is fitted around the shank, soldered to the sheet, and filled with water-proofing compound. These screw-eyes can also be flashed according to the method of Fig. 122.



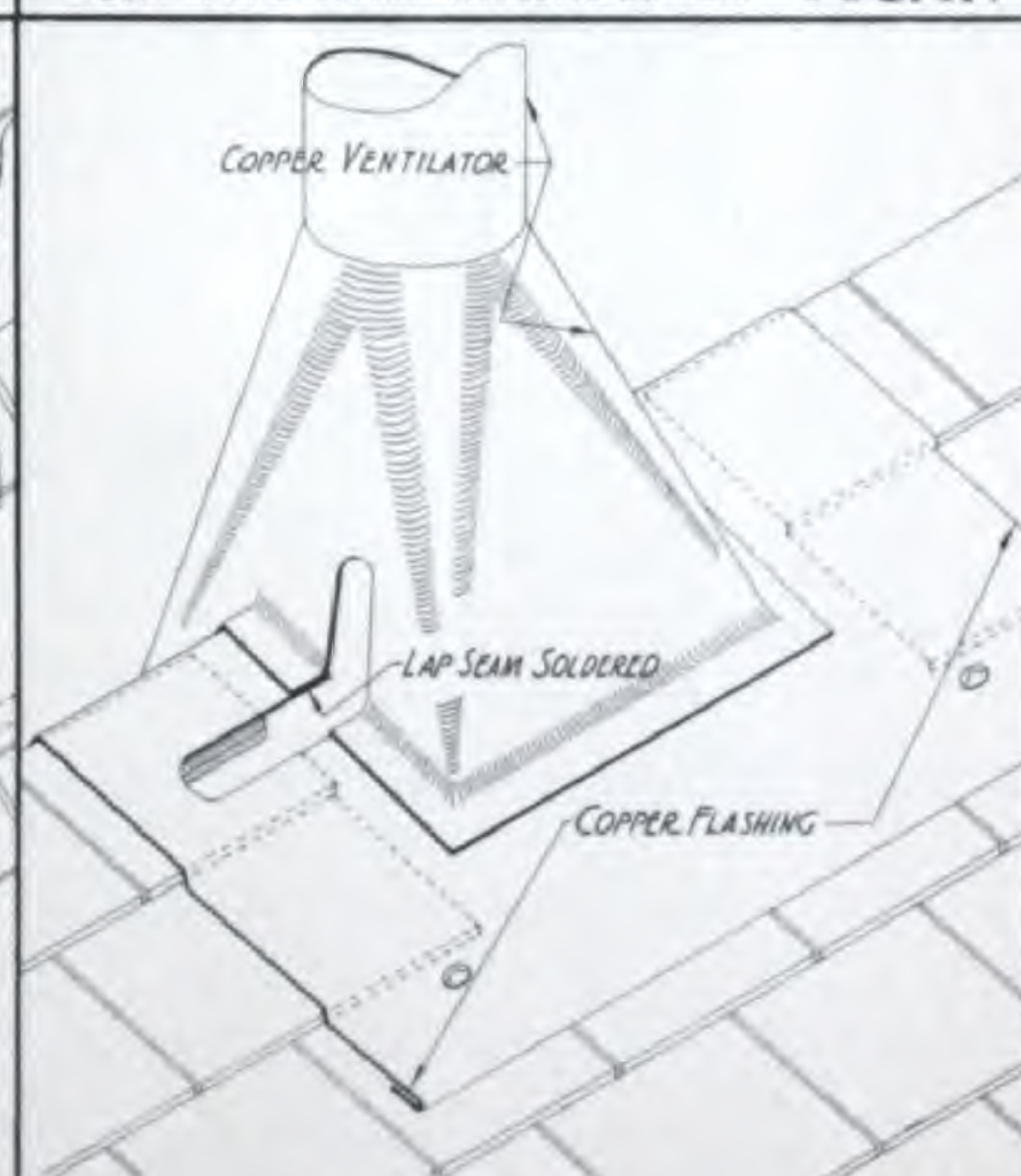
VENT PIPE WITH COPPER CAP FIG. 116



VENT PIPE WITH THREADED CAP FIG. 117



COPPER VENTILATOR ON SLOPE FIG. 118



COPPER VENTILATOR ON RIDGE FIG. 119

Rods and Poles

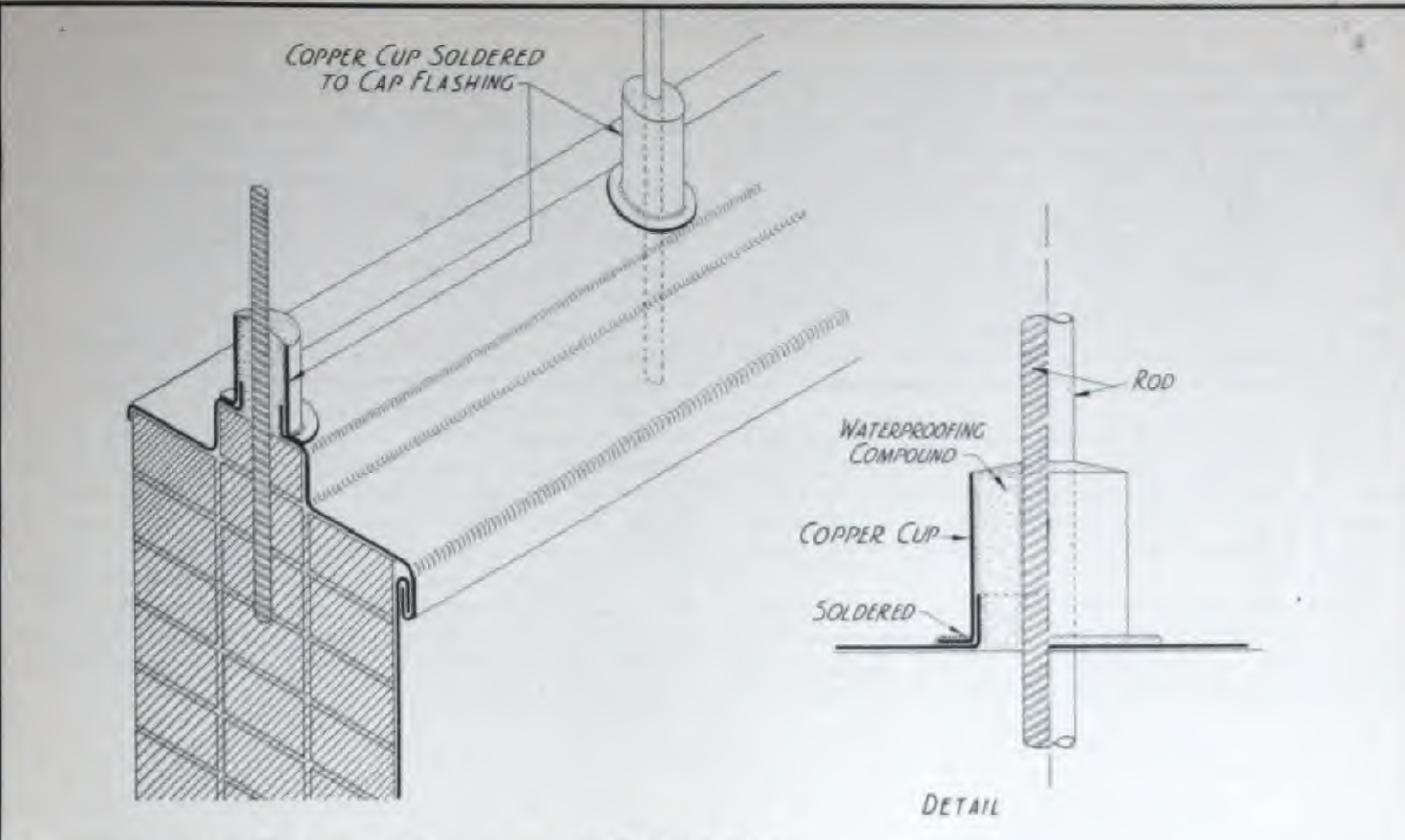
Fig. 120 shows method of forming a flashing cap of copper and securing it to the regular flashing at such places as it may be necessary to penetrate a flashing to permit the passage of rods, dowels, anchors or similar metal shapes. Detail at right shows a half-section and a half-elevation. The cap is shown round, but may be any shape; and it should conform roughly to the contour of the penetrating member. The regular flashing sheet is cut at the points of penetration and the surplus metal turned up. After this is complete the cap is placed. The cap is a cylindrical piece of copper with the lower edge turned out. This piece either is bent around the rod and the ends lapped and soldered, or the ends soldered first and slipped over the top of the rod. The lower edge (previously turned out) then is soldered to the flashing. On completion the cap is filled with waterproofing compound. The cap must be large enough so the sides will clear the rods, etc., at least 1". (See Figs. 103 and 107).

Fig. 121 shows flashing where a flag pole extends through a copper roof. The flashing sleeve is turned out on the roofing and soldered. It must be kept away from the pole to allow for vibration, and is turned out at the top to cut off drifting snow. A flared hood of 20 or 24-oz. copper is placed around the pole, extending down so it will lap the sleeve at least 3". This hood is held by a brass band 1" wide set in white lead and bolted. The lower edge is turned back on itself ½" for stiffness. Very tall poles usually are braced by rods secured to a collar several feet up on the pole. (Method of water-proofing is similar to that in Figs. 120 and 122.)

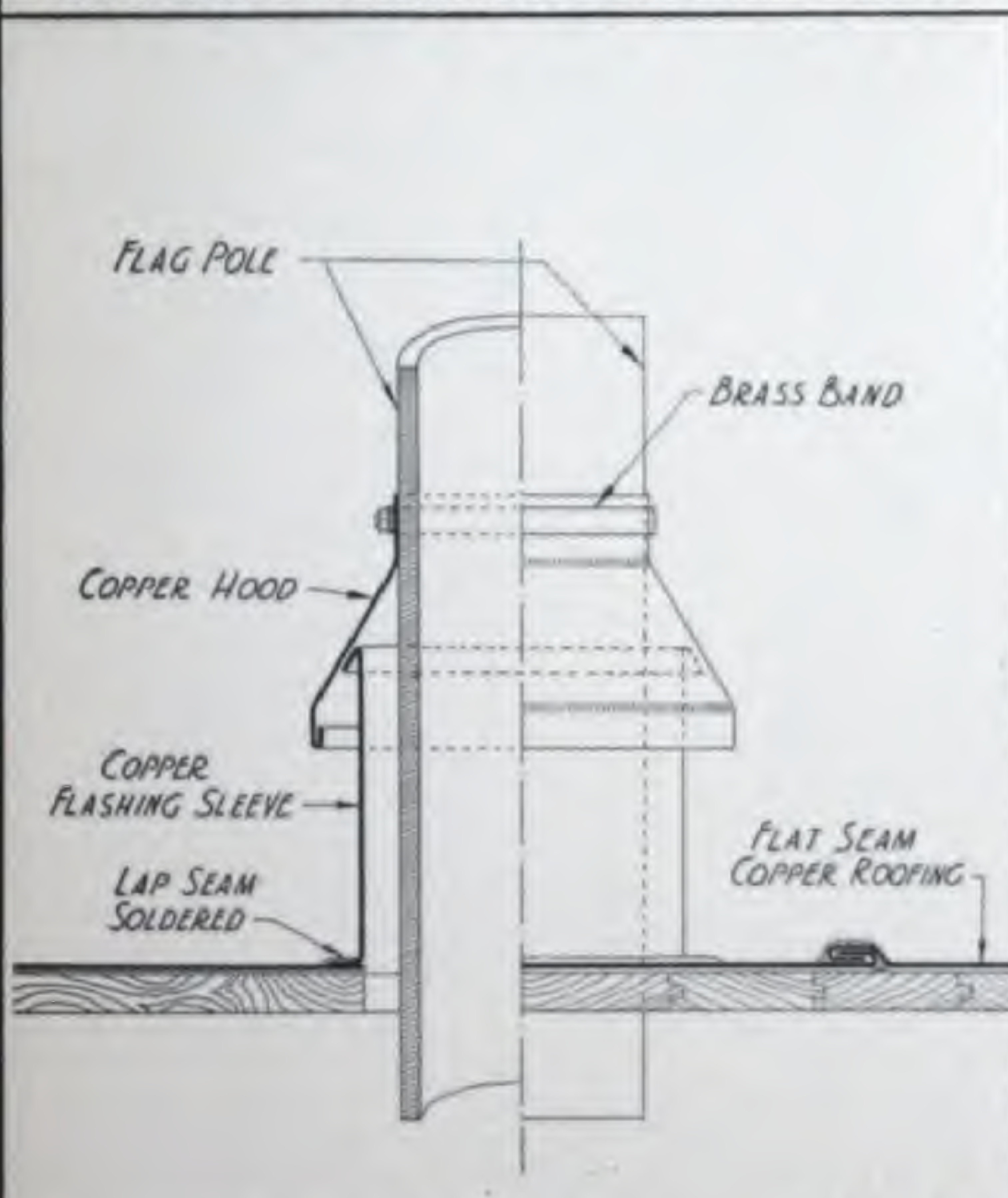
Steel Columns

Fig. 122. Often a roof is pierced by steel members, such as struts, holding a platform or similar structure. Great care should be used at these places, not only to make the penetration point water-tight, but to allow for expansion and contraction of the steel. For this purpose, detail in Fig. 122 is recommended. The composition roof is laid as usual, close to the steel, and a copper collar formed around the steel extending out on the flashing and soldered. For sizeable units 20 oz. metal is recommended. The collar ends are lapped and soldered and the pan thus formed filled with pitch or other waterproofing compound. The steel should be heated with a torch for proper adhesion, especially in cold weather. The part extending out on the roof is covered 4" with two layers of fabric, the copper first having been swabbed with pitch. With a tile roof the flashing is laid on top of the regular roof waterproofing. When necessary to make the vertical and horizontal parts of this pan in two pieces the joint between should be a soldered lap seam.

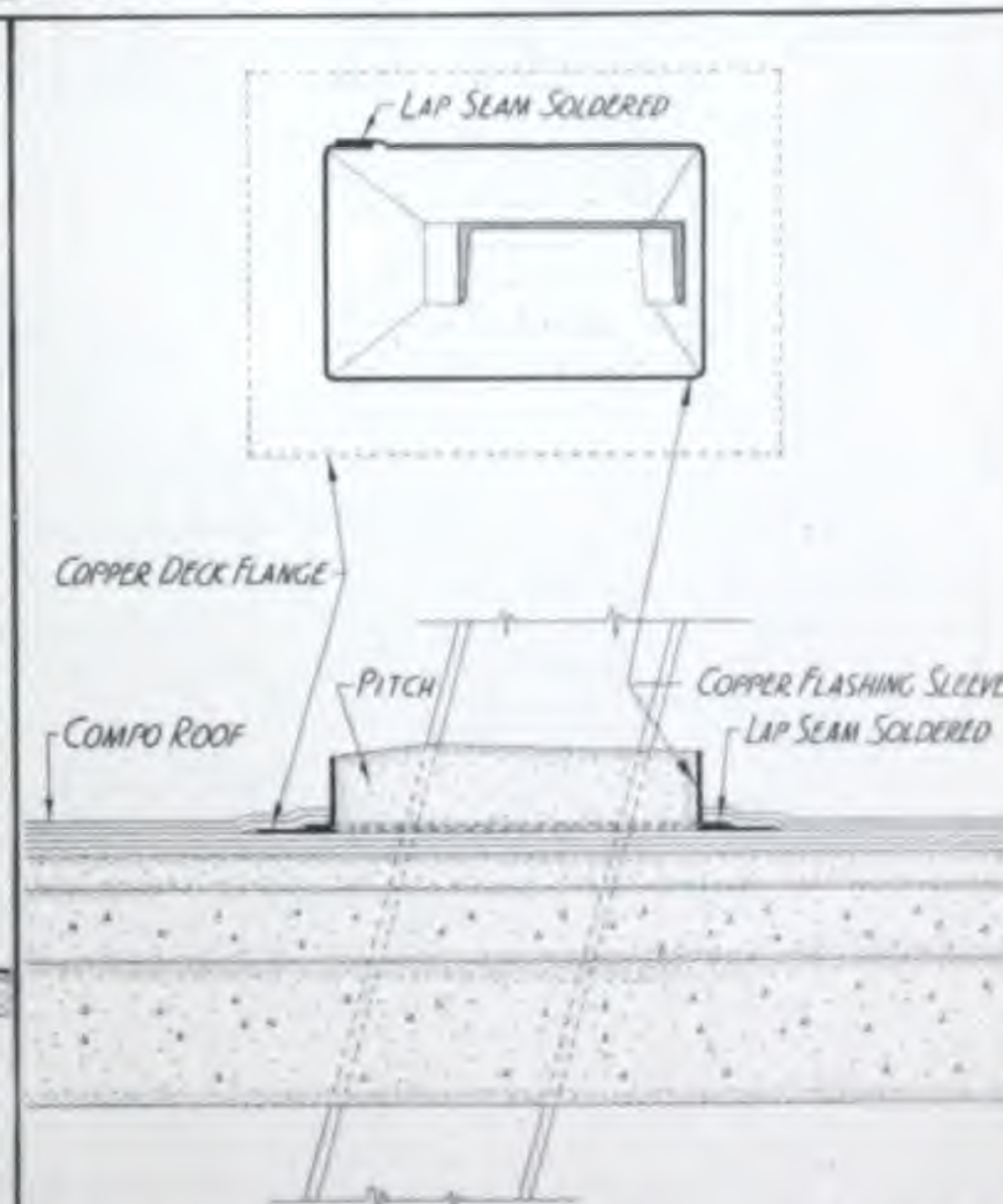
It sometimes is desirable to have this type of flashing and pitch pocket concealed, in which case the construction is similar except that the flashing sleeve runs down into the roof instead of above it. This permits the finished surface of the roof to be flush. This method is applicable to both built-up and tile roofs.



FLASHING FOR RODS OR DOWELS FIG. 120



FLASHING FOR FLAGPOLE FIG. 121



FLASHING FOR STRUCTURAL MEMBER FIG. 122

Flashings for Windows and Doors

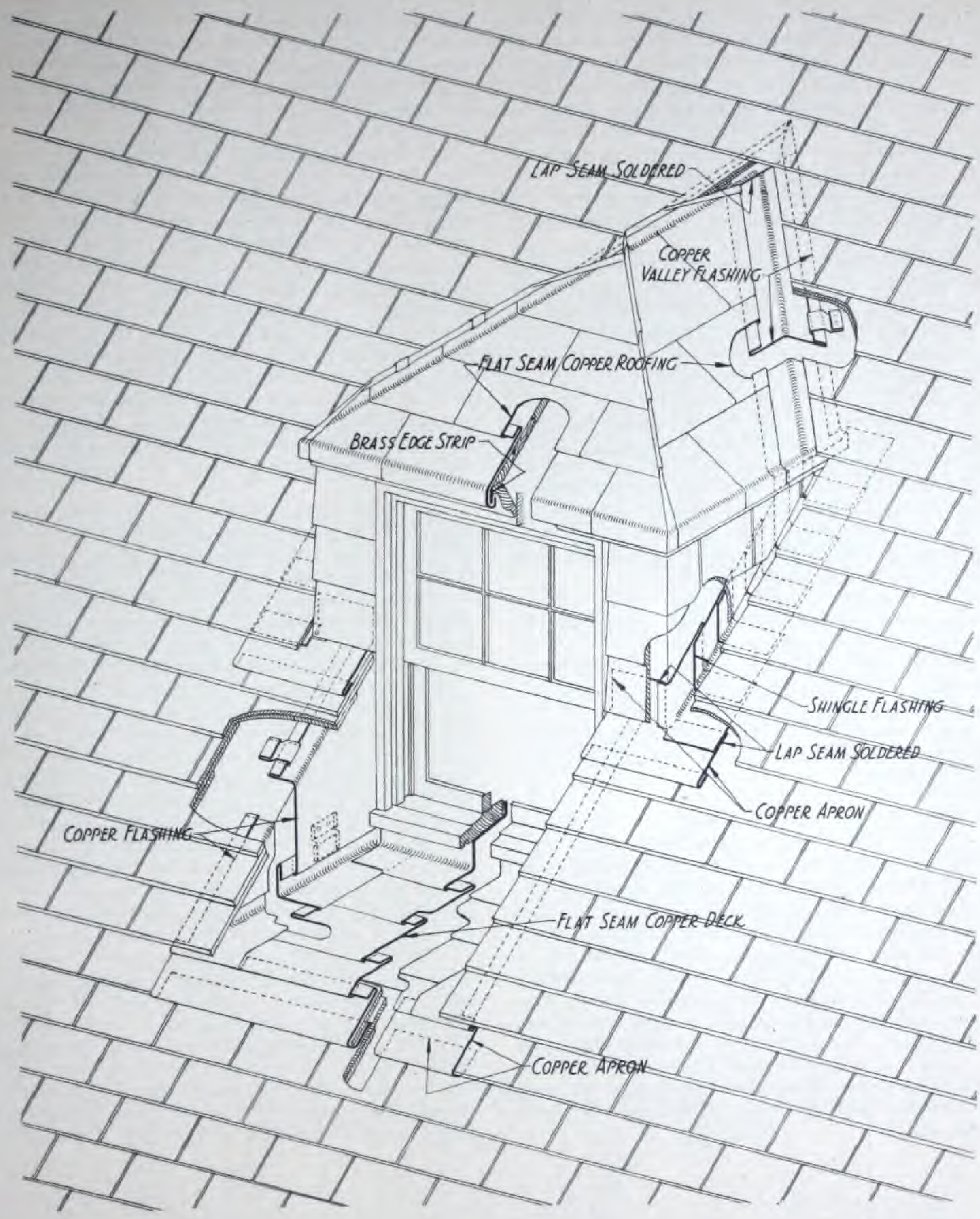
Fig. 123 indicates the method of roofing and flashing a dormer window on the slope of a shingle roof. The window is shown with a recess; but if it is not recessed, the construction is the same at top and sides, and the upper apron merely occurs lower down, to be carried continuously across with shingle flashings under the sill.

The roofing is constructed of 14″ x 20″ copper sheets. The flat-seam method, employing ½″ soldered seams and cleats, should be used for the main seams. Standing seams are formed at ridge and hips. At the edges the roofing is hooked over brass edge strips previously fastened with brass screws to the face of the molding.

Copper open valleys, at the junction of dormer roof and main roof, lock to the copper as indicated and are cleated far enough up on the main roof sheathing to be lapped at least 4″ and be covered by at least two layers of shingles. Where valleys cross at top, the lap seam is soldered.

Above the recess, the flashing construction is analogous to that described in Fig. 113 for chimneys. The copper apron at the window is placed immediately above the shingles, with bottom edge turned back ½″. It should extend out on the shingles at least 4″ and be nailed 4″ up in back of the siding shingles. The corner shingle flashings are soldered to the apron with lap seams as indicated. The balance of the sides are flashed with shingle flashings woven into each shingle course. These flashings should lap each other 3″ and be carried at least 4″ under the roofing and siding shingles, being hooked over the top edges of the roof shingles upon which they rest.

The recess deck is covered with 14″ x 20″ copper sheets laid in the flat-seam method. At the window, a copper flashing strip extends completely through under the sill, as in Fig. 124A, being locked and soldered to the deck copper on the outside. At the bottom a copper apron locks to the lower edge of the deck and extends on to the shingles at least 4″. It can be finished as shown for the upper apron or can be hooked over the shingle butts to prevent wind-lifting. The flashing at the sides of the recess extends up from the deck copper to be carried 2″ under the roof shingles, where it is cleated. At the bottom it is locked to the deck copper which has been turned up for this purpose before it is cleated to the side.



FLASHING FOR DORMER WINDOW AND RECESS FIG. 123

Fig. 124 shows in Details A and A' two methods for flashing a wood window head in a stud wall. In Detail A the flashing is concealed, being covered by the molding. In Detail A' it is exposed, and fastened by nailing along the bottom edge. An alternate method of fastening in the latter is by hooking over an edge-strip. (See Fig. 89.) The edge-strip method is particularly desirable when the trim has considerable projection or when a row of nails would be unsightly. The flashing is placed after the frame and outside trim has been set, but before shingling. It should be carried up at least 3" and must be covered by at least two thicknesses of shingles.

If the wall is stucco, the flashing is usually in two parts, as at the top of Detail C. The cap flashing extends at least 2" up in back of the stucco, and is formed over a board placed on the sheathing flush with the stucco, lapping the base flashing as in Fig. 78. The base flashing is hooked over an edge strip.

Flashing for a window sill is indicated at the bottom of Detail A. It is set after the sheathing and blocking are in place, but before the frame and sill are installed, being nailed to the sill blocking with copper or copper alloy nails. It should extend 4" on to the roof and as far as possible under the sill. The outside edge should be turned back on itself ½", and after the shingles are placed, turned down on them and if necessary, held down with cleats or screws as in Fig. 73.

Detail B illustrates a water bar inserted between a wood and a stone sill as a cutoff to water entering the horizontal joint. The metal strip should be 2" wide and can be of 20-oz. copper or of bronze. Sometimes a folded strip of 16-oz. copper is used. (See Fig. 129E.) The water bar is inserted in a slot in the wood sill and a reglet cut in the stone sill. Just before the wood sill is placed, the reglet is filled with pitch or other waterproofing compound.

Fig. 125. When a wooden doorway or window is placed against a brick wall, as indicated in Figs. 125A and 125B, the junction between the pediment and the wall should be flashed with copper. The brick-work is built up as the building progresses, but the molded wood doorway is not placed until later. For this reason, and also because of expansion and contraction, a two piece flashing (cap and base) usually is advisable.

The cap flashing is built in as the brickwork progresses and each sheet laps outside the next lower sheet at least 3". It may be cut from one or more sheets, by notching upper edges and turning them into the brickwork. The lower edge should be turned back on itself ½" for stiffness, and the sheet should lap the base flashing at least 4".

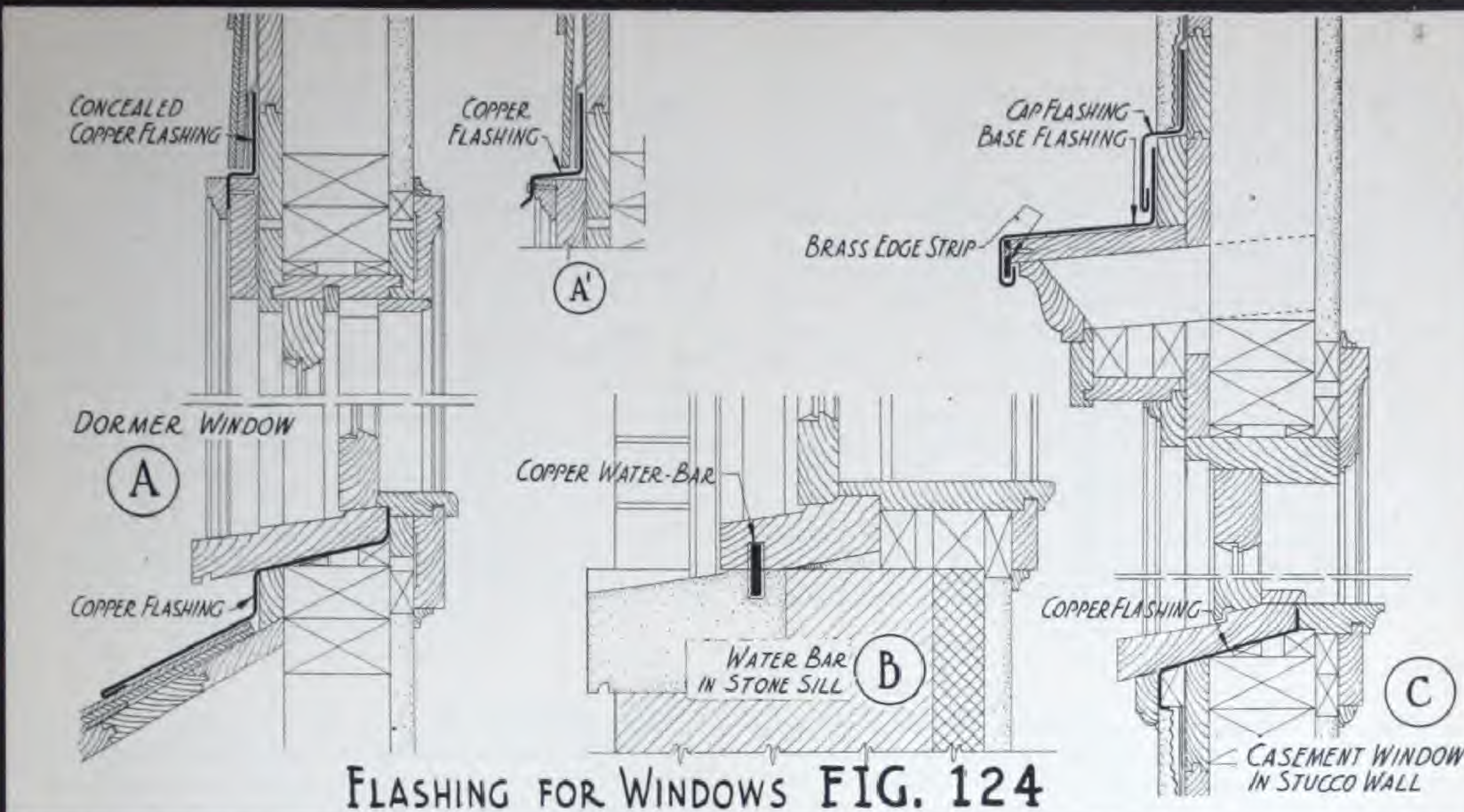
At the bottom left is a sectional view along the lines X-X. The base flashing is hooked over a brass or copper edge strip secured to the wooden cornice with brass screws. The cap flashing is secured in the masonry, back of the first brick, and is folded over the base flashing. If the doorway width requires cross seams, they are made ½" flat locks, cleated down. Ridge is finished with flat-lock seam, as in Fig. 39.

If concealed flashing is desired, the metal enters the wall at a slot flush with the top of the door after the fashion of the base flashing in Section "Y-Y". With large sheets particular care should be taken that they are free to move where they enter the masonry.

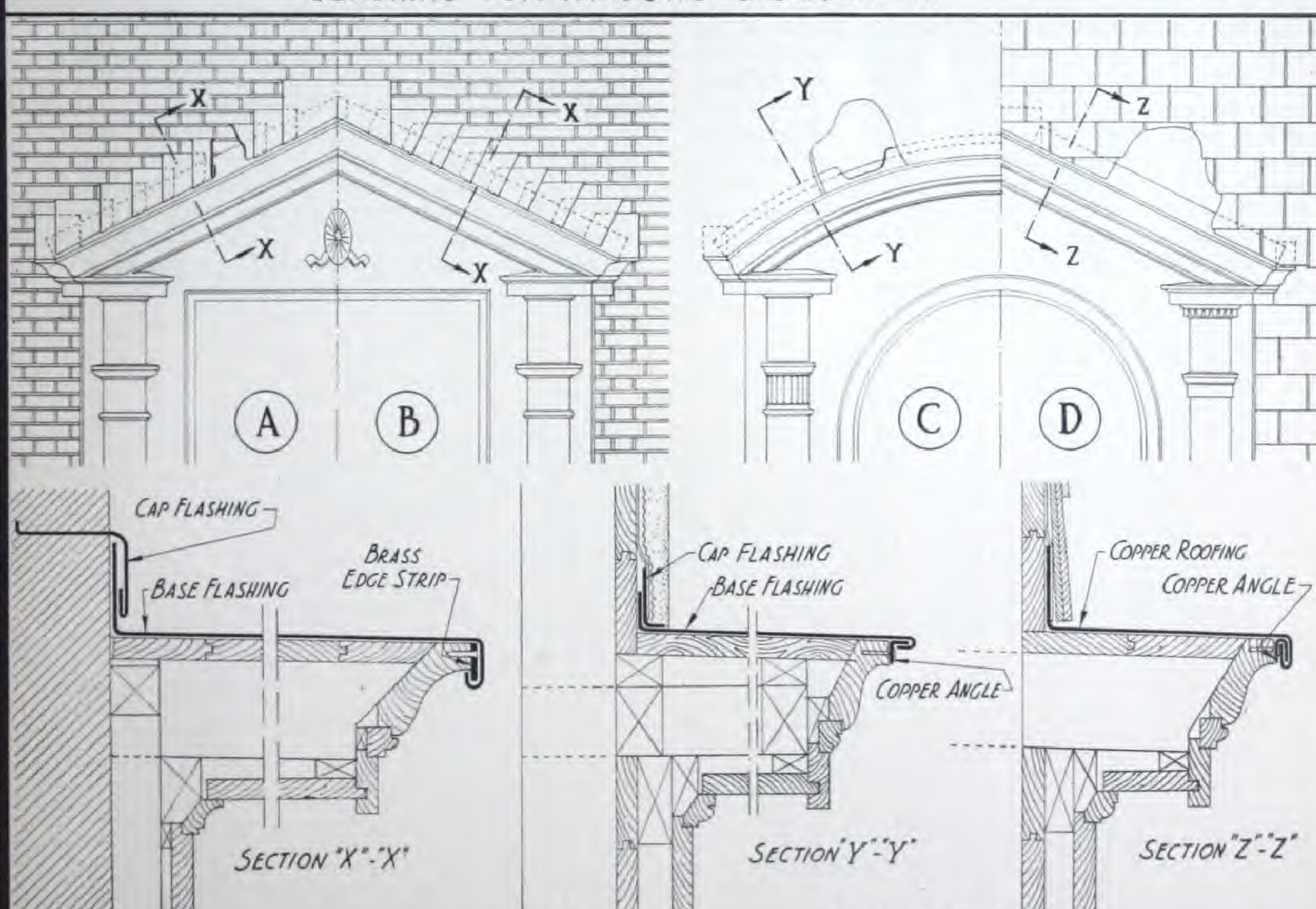
A wood doorway against a stucco or shingle wall is shown in Figs. 125C and 125D. The wood trim will be in place before the stucco or shingles. If the cornice is not wide, and is angular rather than segmental, the flashing may be in a single width instead of cap and base construction. When the doorway has a segmental head as shown at the left, two-piece construction only is practicable, and the length of the sheets on the wall is determined by the sharpness of curvature of the doorway head. Each sheet should lap outside the next at least 3".

In center bottom detail is a sectional view along the line Y-Y, giving construction when top of the doorway is arched. Due to the curve, a vertical edge strip cannot be used, and instead the base flashing is hooked over the horizontal leg of a copper angle previously secured in short sections to the edge of the cornice with brass screws. This lock is ½". For concealed flashing, the base sheet extends across the top of the pediment, and is turned up about 1½" against the sheathing. The cap flashing consists merely of a copper angle of a length suitable to be formed to the curve, with a vertical leg of 2½" or 3" and a horizontal leg of ¾", set atop the base flashing against the wall. It is held by cleats about 18" on centers previously soldered to the base flashing. Building paper or felt, metal lath, and stucco will all lap over the cap flashing strip and extend down to just above the roof line. If exposed flashing is not objectionable, cap flashing construction can be handled as in Fig. 78, though, of course, the curvature of the arch will determine the length of sheets.

Detail D shows construction with a shingle wall when the pediment is angular. The flashing is in one piece, hooked over a vertical drip on the outside and extending up the sheathing back of the shingles 3". To hold the flashing in place until the shingles are applied, it can be cleated to the sheathing at 2' intervals by short folds notched in the edge of the sheet to engage the cleats. With stucco, or, if the cornice is large, the methods in Detail C or Fig. 78 should be used.



FLASHING FOR WINDOWS FIG. 124



FLASHING FOR DOORWAYS FIG. 125

MISCELLANEOUS FLASHINGS AND DETAILS

Gravel Stops

Fig. 126 shows flashing for a roof surface covered with gravel or slag, using a device called a "gravel-stop". It is formed of copper, being applied along the roof edge and secured at side and top. There is a crimp above the roof surface to keep the gravel from washing away. With roofing over wood sheathing, a copper or brass edge-strip is secured along the edge (see page 62), over which the flashing is hooked. The copper should extend on to the roofing 4″ and be nailed to the sheathing with copper or copper alloy nails, after which it is covered with two layers of felt.

The copper never should be laid directly on the roof boards, as the felt will pull away, developing an open joint at the junction of copper and felt. The detail of nailing is not shown in the drawing, nor is the detail for the longitudinal seams that may be required. Here again the length of the continuous run of copper is important. For short runs, say of thirty feet or less, a continuous strip, or eight-foot sheets, lapped and soldered, is satisfactory. For longer runs some provision must be made for expansion and contraction. If conditions permit, an unsoldered lap, or a lock seam, may be used.

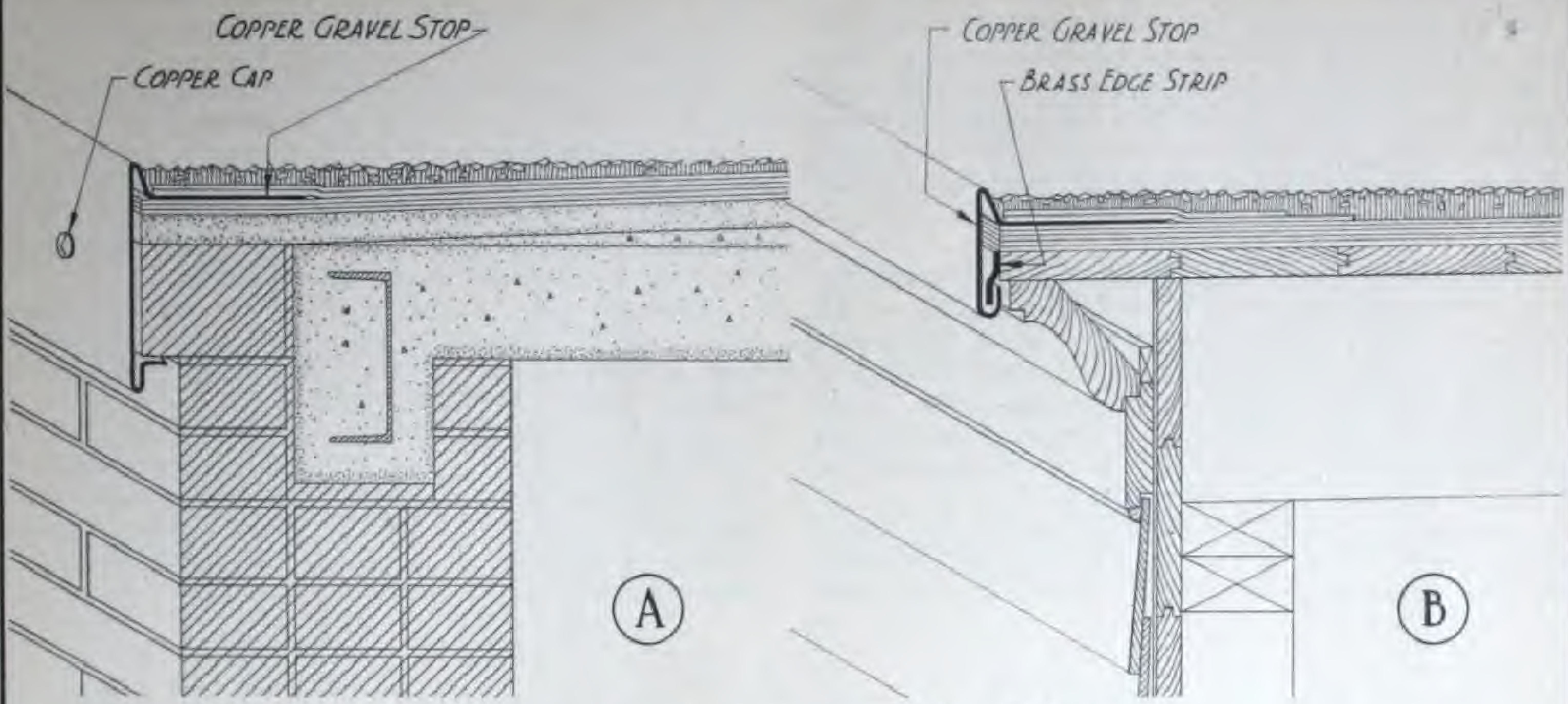
Detail A shows a gravel-stop flashing at the edge of a roof laid on concrete slabs. It is secured with brass screws and lead washers or brass and lead expansion bolts. Holes are drilled into the bricks or slabs about 12″ apart and $\frac{3}{8}$″ in diameter. If expansion bolts are not used, small cylinders of sheet lead slightly shorter than the depth of the holes are inserted. Brass wood screws with slotted washers then are used to fasten the copper as detailed in Fig. 103. To prevent water entering the screw holes, copper caps can be soldered over the heads as outlined in Fig. 118.

Instead of forming the flashing sheet itself into the gravel stop, a separate crimp may be soldered on to the flashing as shown in Fig. 110.

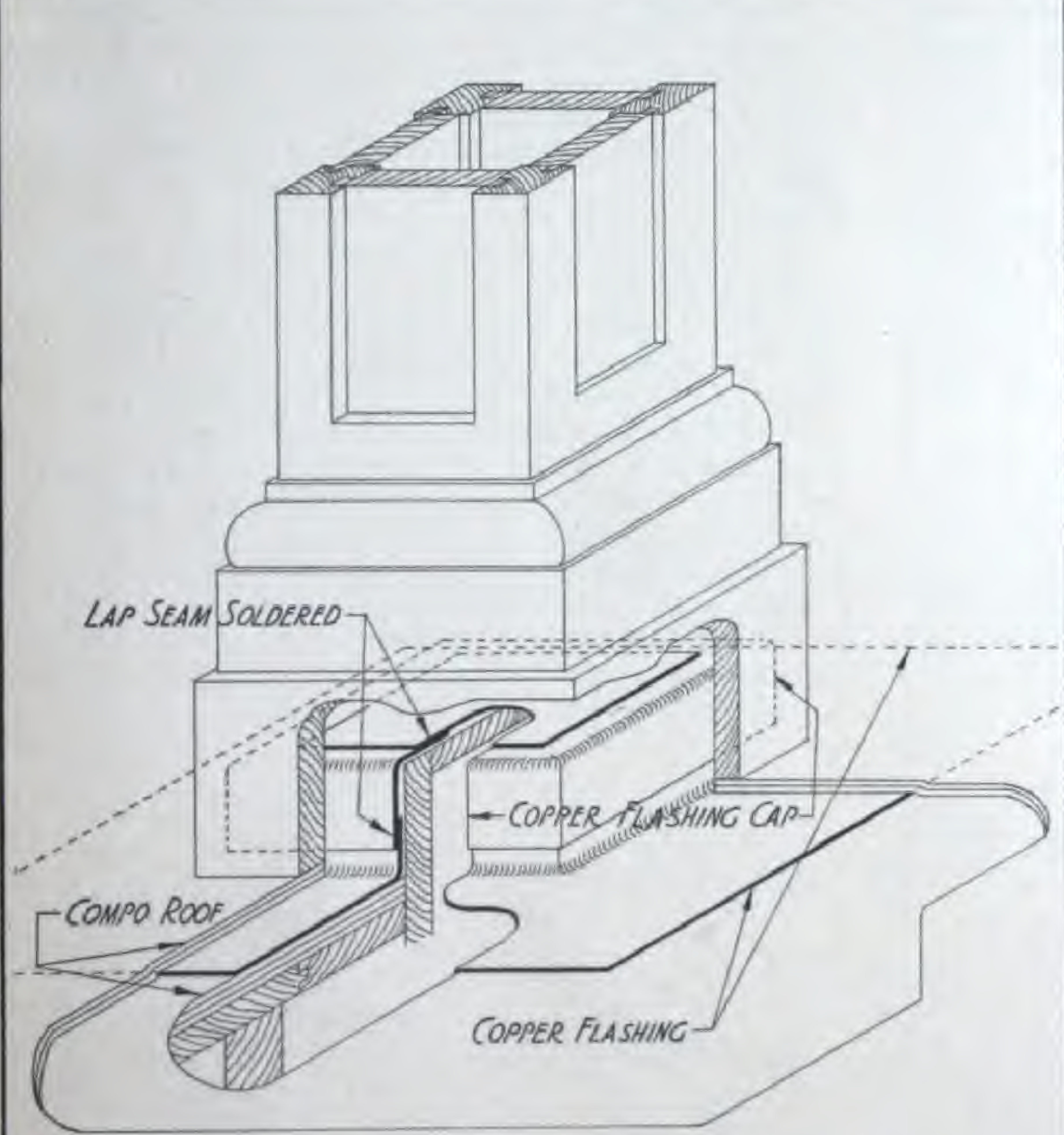
Wood Columns

Fig. 127 indicates the method of flashing a place where the base of a wood column rests on or penetrates a composition roof laid over wood, providing a watertight junction. This usually is made into one unit by soldering, and is placed either over the dowel on top of the column below, or over a projection raised on the deck. If the base is more than 6″ high, the flashing should be broken at the vertical faces, the cap and base method being used. The copper should extend on to the roof at least 6″ and be set in the layers of felt. The upper column is placed over this cap and rests on top of it. The sides of the column base should clear the composition roof from $\frac{1}{2}$″ to 1″ to prevent rot. The above method with slight variations is used for round wood columns as well as square columns.

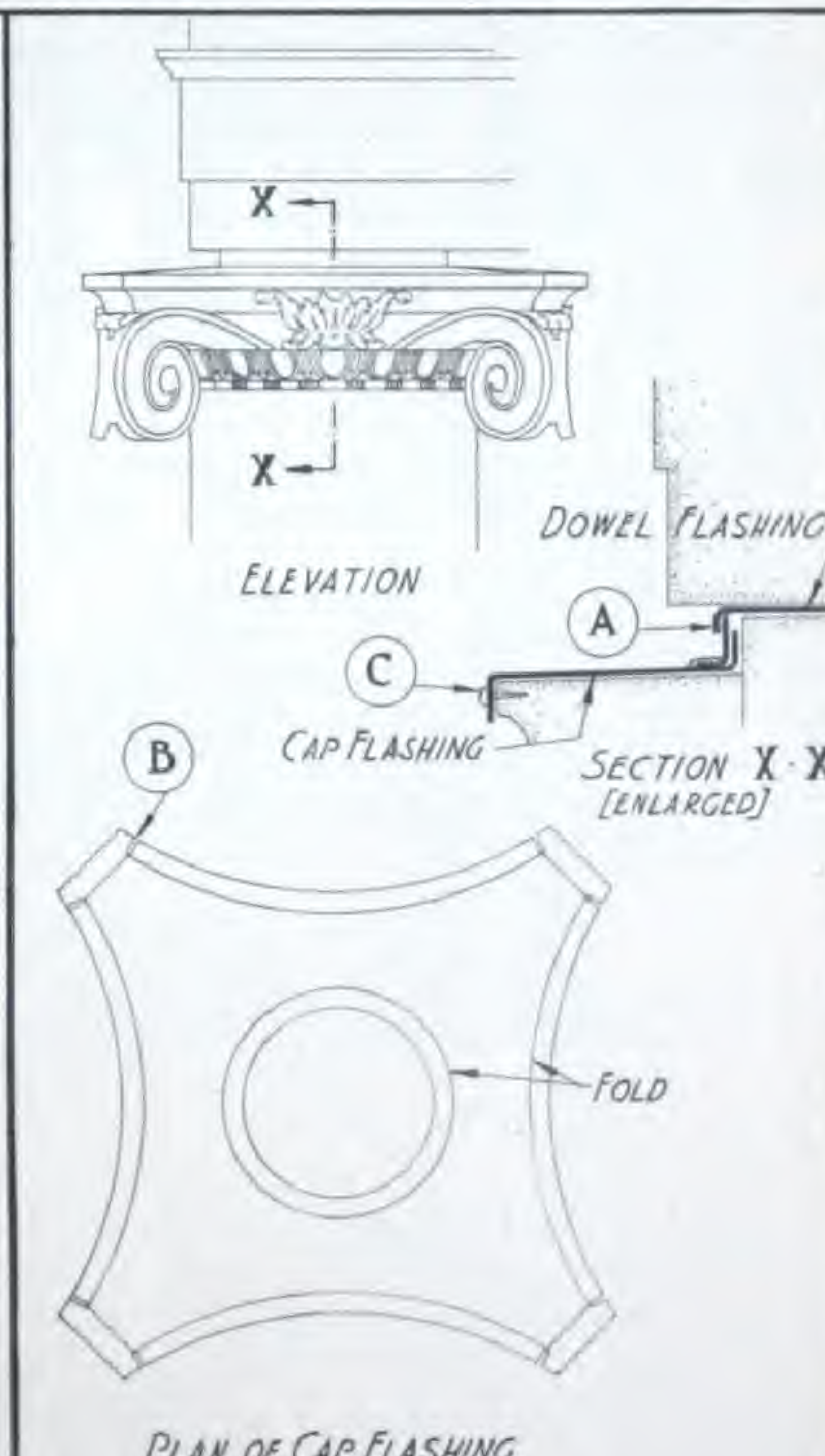
Fig. 128 shows method when a wood or composition column-cap is exposed to action of the elements and the upper surfaces of the projecting parts should be flashed to protect them from dampness and seepage. The disk-shaped portion over the dowel is cut and formed separately slightly larger than the dowel. It has a $\frac{1}{4}$″ edge turned down all around, to which an additional angle strip is soldered before the circular piece is placed, as shown at "A" in the sectional view. The balance of the flashing is made in one piece, with inner edge turned up about $\frac{3}{8}$″ against the dowel and soldered to the horizontal leg of the angle on the dowel cap. Notches are cut as at "B" to allow a $\frac{1}{2}$″ turn-down secured with brass screws or nails as shown at "C". The $\frac{1}{2}$″ edge flange can be widened to form a drip.



GRAVEL STOPS FIG. 126



COLUMN BASE FLASHING FIG. 127



COLUMN CAP FLASHING FIG. 128

Half-Timbered Work

Half-timbered walls need proper flashings to be wind and weather tight. The wood members shrink away from the stucco or brickwork and leave small openings. Brick veneer, whether or not with half-timbering, needs flashings and wind breaks in exposed locations. Proper drainage should be provided through weep-holes at the base of all walls of this type.

Fig. 129 indicates flashings for half-timbered work, with stucco shown at the left and brick veneer at the right. At "A" is shown the flashing of a water table or band course. The exposed edge of the flashing is fastened, either by nailing, or by an edge strip. (Compare Fig. 83.) The flashing runs behind the metal lath and paper, making a complete cut-off. Weepers drain moisture collecting back of the stucco.

Horizontal members are flashed along the upper surface and at the corners as indicated at "B". The flashing turns out at the vertical members. It is held by the building paper nailing, and the exposed edges are turned out over the wood about ¼".

A band mould in brick veneer is flashed as indicated at "C". This is similar to the construction at "A" except it is carried through the brickwork and turned up the sheathing back of the building paper. Dry joints are left in the masonry immediately above the flashing for drainage. At "D" is shown a wind break in a window jamb to cut off water driven into the joints.

Flashing under a window sill, and a water bar are shown at "E". The water bar is an important weather stop, and may be folded from 16-oz. sheet as suggested here, or a bronze bar used as in Fig. 124.

The flashing over the window head, as at "F", is continuous back of the face brick and is turned out at the vertical timber members. The lower edge turns down over the cornice fillet and is held with concealed nailing. A wind break is placed back of the trim as shown at "D".

TERMITE PROTECTION

Until quite recently the menace of termites has been confined to restricted areas of the United States, chiefly on the West Coast. More recently these destructive insects have invaded the East and are to be found in practically every state in the country.

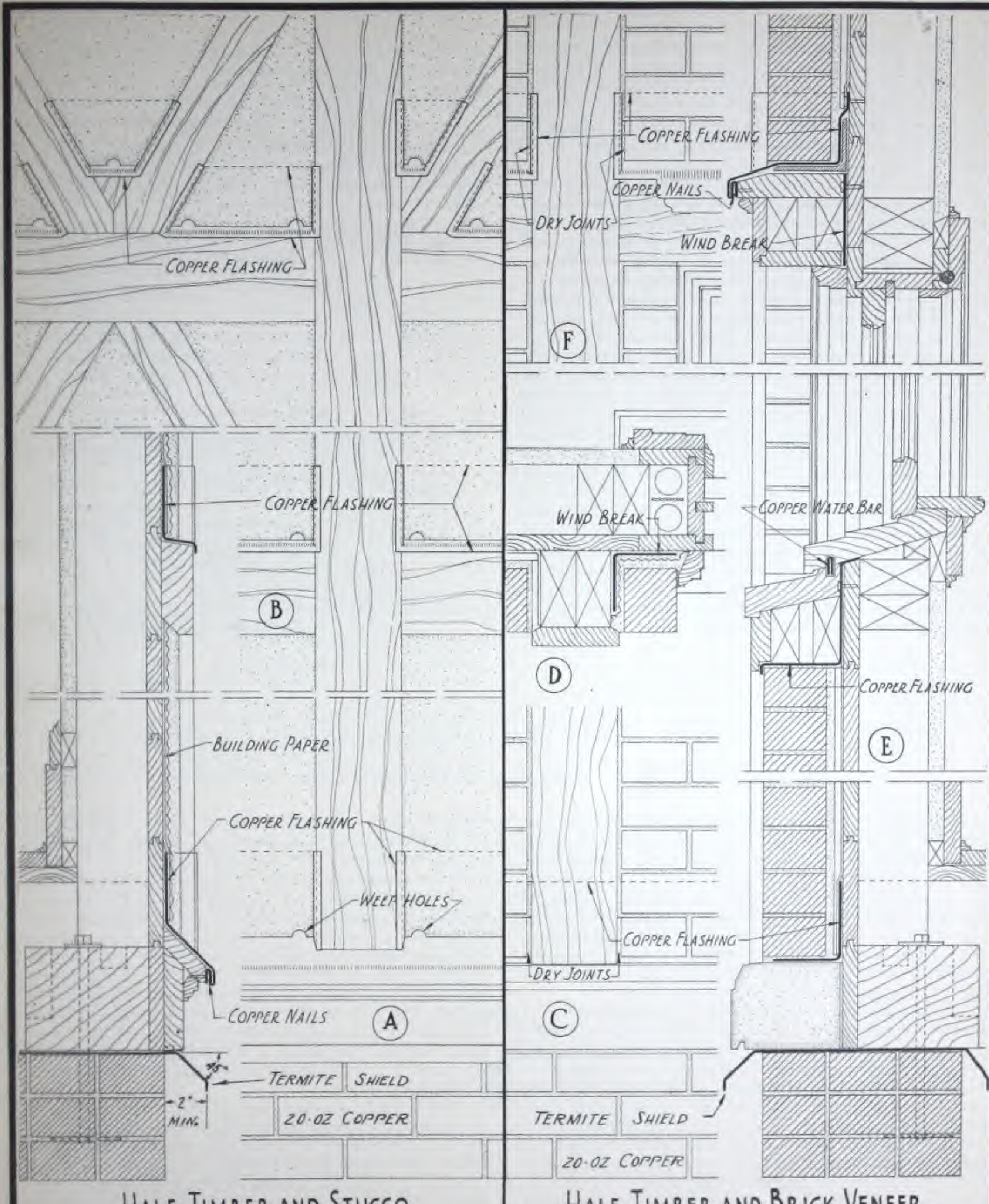
Termites work their way from the earth into the wood construction of buildings not specially protected against their invasion. They will even build shelter tubes over the masonry and other impenetrable materials in order to pass under cover to the supporting timbers and other woodwork of a house. There, unseen and often unsuspected, they proceed to carry on their destructive work.

More than 95% of the termites are of the "underground" type, which, to live, must maintain their contact with ground moisture through these shelter tubes. Full details about termites, their habits, and how to deal with them are contained in a leaflet issued by the U. S. Department of Agriculture entitled "Injury to Buildings by Termites".

The essential thing in dealing with Termites is to cut them off from their contact with ground moisture as indicated above. This is effective both for houses which they have penetrated (and mostly their work is under cover and will not be evident until a wooden beam which they have devoured fails) and for new and unaffected structures.

Shielding of 20-ounce Copper, used as indicated in Fig. 129 is one of the most effective ways of dealing with this problem. The copper shield cuts off the termites from the ground moisture. Copper will outlast other types of metal shields that may be employed.

The 20-ounce copper is laid in 8′ standard sheets, projecting from the face of the wall, turned down at 45° and then turned down a short distance vertically. The vertical leg should be not less than 2″ from the face of the wall, preferably 2½″ to 3″. The 8′ lengths of copper are joined by ½″ soldered lap joints, or ¾″ lock joints. The shield should clear the ground by at least 18″ and no unprotected wood should be lower than that height.



HALF TIMBERED WORK FIG. 129

COPPER CORNICES

The use of sheet copper for cornices is common practice and has many advantages. Sheet metal is light and easily worked and shaped, which makes erection less expensive than stone and terra cotta. These features, coupled with the enduring qualities and pleasing appearance of copper well justifies the popularity of copper cornices.

Sheet metal cornices have an additional advantage in increased safety, as sections do not become dislodged from the action of ice and frost in mortar joints. Many varieties of design and construction are possible, and each case must be treated as an individual problem.

Loose-lock seams should be employed between sections of the cornice, their location being determined by the contour and design of the case in hand, and the fact that water must not be allowed to enter the seams. If the sheet covering the cornice deck is more than 2′ in width a cap and base flashing should be used at the wall. Sheets should not be nailed when the supporting structure is wood, brass screws with lead washers being used for such fastening. Metal supports, braces, and lookouts generally are required by building codes and copper alloy bolts or screws should be used for fastening the copper to them. Longitudinal joints should be either loose-lock seams, or made by folding back the edges of adjoining sheets in opposite directions and joined with an auxiliary strip similar to an expansion joint cap. For sheets more than 3′ or 4′ long enlarged holes should be provided for all screws or bolts so movement will not be restricted. Fig. 118 shows the copper caps to be used over such enlarged holes.

Following are summarized the salient points in the construction of copper cornices:

(1) Use at least 16-oz. hard (cornice temper) copper, either plain or crimped.

(2) All metal supports and fastenings should be of brass or other copper alloy. If other metal is used it must be insulated from the copper. (See page 5.)

(3) Sufficient lookouts, braces, supports, stiffeners, and anchors should be provided to give a rigid construction and they must be well secured or anchored to the building.

(4) Use brass bolts or screws with lead washers and slotted or enlarged holes where necessary to permit movement. These should be placed so as to be inconspicuous and not buckle the sheet metal.

(5) Sufficient loose-locks and expansion joints should be provided to care for expansion and contraction of the copper.

(6) Where tight seams are required they should be riveted as well as soldered. This applies also to the application of ornamentation and enrichment on the surface of the cornice.

(7) Provide drips where required to prevent water running down the cornice face.

KEEPING BUILDINGS DRY

By Cecil Fidler, Engineer of Standards, Atlantic Terra Cotta Co.

There is no doubt that in the past the importance of flashing in building construction has not been fully recognized. It has long been the custom to flash gutters and to use flashing at the junction of roofs and parapets, but it is only recently that designers and owners of buildings have begun to realize the necessity for flashing the entire upper and rear surfaces of exposed architectural features. It is now becoming evident that more attention must be paid to the protection of parapets and copings, cornice tops and balcony floors.

An extensive examination of buildings erected in the last thirty years shows conclusively that the saturation of cornices and parapets is a very prevalent condition. In some cases the water enters at the mortar joints in the top of the coping. In other cases rain beats in and soaks in at the joints in the back of the parapet wall. Very frequently the mortar joints in the wash of the cornice are so cracked and porous that a lot of the water that runs down the parapet or falls on the top of the cornice finds its way into the interior of the wall.

Many architects and owners find that they have been placing too much reliance on mortar joints. Having procured weatherproof building materials, such as terra-cotta or hard stone, and having specified mortar of tested ingredients and approved mixture, they supposed that their buildings would be water-tight when erected. They are now finding that a great many buildings are not water-tight and on searching for the cause, they usually discover that the water is getting in at the mortar joints in the wash of the cornice and parapet coping.

At a first glance, it might appear that by carefully caulking or grouting the joints in the wash of cornices, parapets and balconies, it should not be very difficult to make them water-tight, but the present condition of a great many of these features proves that for one reason or another, water-tight joints are not being obtained. The bad condition of the mortar joints may be attributed to a variety of reasons, as for instance, poor workmanship, poor mortar, disintegration by frost, or cracking of joints due to thermal expansion and uneven settlement.

Many kinds of elastic cement and various caulking compounds for the protection of mortar joints are on the market and some of them remain impervious and somewhat elastic for several years but none of them appears to retain its original qualities indefinitely. Protection by means of caulking compounds involves periodical examination and considerable maintenance.

The results of poor joints are far reaching. The most common visible damage due to leaky joints in washes is unsightly staining and streaking on the face of the architecture. This staining and streaking is often ex-

tensive enough to destroy the beauty of a costly building. Frequently the streaks and discolorations clearly indicate that soluble portions of the mortar are seeping out at the beds and joints and are being deposited on the face of the building. Such a condition as this if allowed to continue will rapidly bring about the disintegration of portions of buildings on which it occurs.

Another serious result of leakage at joints is damage to plaster ceilings and walls within the building. Cases have been known where water entering at leaky joints in the washes of cornices and parapets has penetrated the walls to the depth of several stories below, causing considerable damage to the paint and plaster on the inside of the walls.

A still more serious condition, worse because it is out of sight, is the effect of dampness on steel framework within cornices, balconies and balustrades. The presence of moisture leads to rapid corrosion of the steel members and may eventually render projecting features unsafe.

Architects and owners of buildings have also to consider the damage that is caused by the freezing of water that collects in pockets and open spaces in the interior of walls and structural features. The expansion of ice repeated through a number of winters may finally rupture the masonry.

As impervious joints are difficult to obtain and expensive to maintain and as neglected leaks result in damage to valuable buildings it is advisable to cover wash surfaces with an impervious and permanent covering. **Sheet copper is believed to be the most suitable material for this purpose.**

Flashings should be carried entirely over the top of cornices and in most cases should be turned down over the nib far enough to form a drip and allow the water that runs down the wash to fall clear of the moldings. In this way the face of cornices may be kept clean and free from stains of any kind. When the top of a cornice is flashed, it is advisable to carry the flashing entirely through the base of the parapet and connect it with the cap flashing at the back of the wall. In this way water which enters at the top of the parapet is prevented from getting down behind the flashing at the back of the wall and is also prevented from getting underneath the flashing on the top of the cornice. The backs of parapets should be flashed whenever possible and the flashing should be carried over the top of the wall, laying it in the bed joint immediately below the coping. Then, if there is any leakage at the joints in the wash of the coping, the water cannot get behind the flashing, as it often does when the flashing is applied only to the back of the wall.

The unsightly discoloration that is so much in evidence on the underside of balconies indicates the necessity for better protection of these features. It is almost impossible to make the deck of a balcony water-tight by means of a cement or tile finish. A covering of sheet metal should be used in all cases. In flashing the tops of balcony slabs with sheet metal it is necessary to run the flashing out to the nib if the best results are to be obtained. Quite frequently the floor of a balcony is properly flashed, but the flashing terminates in reglets in the base of the balustrade. This practice almost invariably results in the saturation of the balcony slab by water which finds its way in at the joints in the balustrade and runs down behind and underneath the flashing. By carrying the flashing underneath the base course, any water that enters at the joints of the balustrade cannot penetrate to the balcony slab, and the soffit of the balcony is kept dry and unstained.

The washes of pediments and dormers should be completely flashed if staining and other evils of saturation are to be avoided.

While the use of sheet metal for the protection of mortar joints in washes may entail some slight additional expense at the time of the erection of the building, it will be found more economical in the end because the cost of maintenance will be avoided. Moreover, a building that is properly protected at the beginning will retain its original beauty and value.

This standing seam Copper roof of the cathedral at Hildesheim, Germany, is the oldest known Copper roof in the world. Portions of it have been untouched since it was laid in 1320, while the gilded Copper cupola was completed in 1367.

SECTION IV—DRAINAGE & ACCESSORIES

It seems scarcely necessary to point out that an ideal drainage system must be designed so it will carry away the water shed by the roof of the structure in question most efficiently. As has already been pointed out, the roofs, flashings and valleys should be constructed to shed the water and turn it toward gutters and outlets as speedily as possible. The drainage system should carry on this objective by conducting the run-off to the ground or sewers, and should not be a storage place for water. Gutters and leaders should have capacity for the maximum amount of water which they will be called upon to handle, and yet making them too large is wasteful and leads to other difficulties as well. Outlets should be designed to transfer the horizontal gutter flow into vertical leader flow with the greatest efficiency.

The need for and proper installation of flashings and valleys at various critical points of the roof have already been brought out, and the construction at the points where roofs or valleys meet gutters, and at leaders, outlets, scuppers and strainers is of equally great importance. Some installations which have been entirely satisfactory in other regards have given trouble due to faulty design or construction of the drainage system.

The most common faults in gutter and drainage design are:

1. Gutters too small.
2. Outlets too small or of improper shape.
3. Improper spacing or number of leaders.
4. Expansion and contraction neglected.
5. Lack of scuppers or overflow drains.
6. Improper provision for snow and ice.

If the gutter is too small or if the outlets will not permit the leaders to empty the gutter fast enough, water or snow either backs up behind flashings and leaks into the building, or spills over the outside causing staining and other troubles.

If the leaders are insufficient in number, too small, or spaced too far apart, the water is not drained fast enough and overflow results.

Expansion and contraction must be cared for or the metal will buckle and break, and leaks result.

If scuppers or overflow drains (see Fig. 112) are not provided for enclosed roof areas, outlet stoppage will cause an overflow into the building.

If built-in gutters are too deep, have sides too vertical, and are too flat, the expansive thrust of freezing ice will cause breaks and leaks.

Gutters should have all the slope possible, which means high points and short runs in shallow gutters between carefully spaced outlets. Straight steep sides restrict the movement of the metal and may also cause trouble from freezing ice.

The type of strainers used at outlets is important. Outlets should be provided with guards to prevent leaves, twigs, sticks, paper and other rubbish from clogging the drains, but improper strainers often do more harm than good by impeding drainage entrance into the outlets or by giving way and being washed part way down and jamming the drains. Only copper wire or cast brass or bronze strainers of proper design should be used. The steady attack of flowing water will soon break down a corrodible material. Cast brass or bronze strainers are best for large outlets as they have greater strength than wire.

PROPORTIONING GUTTERS, LEADERS & OUTLETS

The design of the various portions of a drainage system as far as capacity is concerned is dependent upon the amount of water to be handled. This in turn depends upon the rainfall in the particular locality and the amount of roof area tributary to the unit in question.

The roof area used in computations should be the actual area and not the horizontal projection of the area. Rain seldom falls vertically, and the maximum condition exists when it strikes perpendicular to the roof surface, making the total area effective.

RAINFALL DATA

The rainfall data to be used in the design should, naturally, apply to the locality in which the structure is to be located. Conditions throughout the country vary and the use of an average figure would be illogical as it would result in inadequate provision in some cases and waste of material in others. The type of structure for which the drainage system is being designed also should be considered. A storm of maximum intensity may occur only once in twenty or thirty years in a certain locality, while a lower rainfall intensity will be exceeded only once in ten years. If gutter overflow is a matter of inconvenience only, or if the design can incorporate auxiliary drains to care for the excess, the lower intensity may well be used for sake of economy. In residential construction, for instance, no great harm may result if water spills over the outside of gutters during one storm in five years, and the use of the corresponding intensity of rainfall rather than one which will never be exceeded may result in considerable saving. On the other hand, the architect may be designing a monumental building where the construction of built-in gutters with cornices, parapets, etc., is such that an overflow would have most serious consequences, and here he could well afford to design for absolute maximum conditions. Such questions of judgment are entirely up to the designer and no hard and fast rule can be set down.

The U. S. Department of Labor has compiled charts for 23 cities throughout the country for which the U. S. Weather Bureau has included data of excessive rainfalls in its annual reports. In most cases these records begin about 1896, but few storms were recorded in the early years so that there may be some discrepancies particularly for the cities west of the Mississippi River, and where absolute safety is necessary this fact should be borne in mind. These records were used unadjusted in compiling the table in Fig. 130, which will be found on the following page.

LEADER DESIGN

	(A) Storms Which Should Be Exceeded Only Once in 5 Years		(B) Storms Which Should Be Exceeded Only Once in 10 Years		(C) Maximum Recorded Storms	
	Intensity in Ins/Hr. Lasting 5 Minutes	Sq. Ft. of Actual Roof Drained per Sq. In. of Leader Area	Intensity in Ins/Hr. Lasting 5 Minutes	Sq. Ft. of Actual Roof Drained per Sq. In. of Leader Area	Intensity in Ins/Hr. Lasting 5 Minutes	Sq. Ft. of Actual Roof Drained per Sq. In. of Leader
Albany	6	200	7	175	7	175
Atlanta	7	175	7	175	9	130
Boston	5	240	6	200	7	175
Buffalo	5	240	5	240	10	120
Chicago	6	200	7	175	7	175
Detroit	6	200	6	200	7	175
Duluth	5	240	6	200	7	175
Kansas City	7	175	8	150	10	120
Knoxville	5	240	6	200	6	200
Louisville	6	200	7	175	8	150
Memphis	5	240	6	200	10	120
Montgomery	7	175	7	175	7	175
New Orleans	7	175	7	175	8	150
New York City	6	200	8	150	9	130
Norfolk	6	200	7	175	8	150
Philadelphia	6	200	7	175	8	150
Pittsburgh	6	200	6	200	7	175
St. Louis	6	200	8	150	11	110
St. Paul	6	200	6	200	8	150
San Francisco	2	600	2	600	3	400
Savannah	6	200	7	175	8	150
Seattle	2	600	2	600	2	600
Washington	6	200	7	175	8	150

Fig. 130. Rainfall Data and Drainage Factors

In the design of leaders, it should be realized that practical considerations enter as well as principles of hydraulics. It is obvious that more water will drop through a vertical pipe than will flow in a horizontal trough of equal area. Therefore it might appear that the leader could well be much smaller than the gutter and still take care of all the water coming to it from the gutter; moreover, it might seem that the leader can be tapered in size as the velocity of the falling water increases with the drop. These inferences would follow if only pure hydraulics were involved.

Experience has shown, however, that due to practical considerations the following principles should be followed:

(a) 3" round or 1¾" x 2¼" rectangular leaders should be the minimum (except for small porches).

(b) Leader area should be constant throughout its length.

(c) 75′ maximum spacing is recommended.

With item (c) in mind, the locations of the leaders are first determined. If possible, they should be placed near the corners of the building so that the gutter water will not be required to flow far beyond a sharp turn. Gutter expansion joints, being necessarily at high points, will often govern intermediate leader location. Of course, appearance and other architectural considerations will also play a decided part in the layout

With the locations determined, the areas tributary to each leader should be computed. Actual roof areas

Type	Area in Sq. In.	Nominal Leader Sizes
Plain Round	7.07	3"
	12.57	4"
	19.63	5"
	28.27	6"
Corrugated Round	5.94	3"
	11.04	4"
	17.72	5"
	25.97	6"
Polygon Octagonal	6.36	3"
	11.30	4"
	17.65	5"
	25.40	6"
Square Corrugated	3.80	1¾" x 2¼" (2")
	7.73	2⅜" x 3¼" (3")
	11.70	2¾" x 4¼" (4")
	18.75	3¾" x 5" (5")
Plain Rectangular	3.94	1¾" x 2¼"
	6.00	2" x 3"
	8.00	2" x 4"
	12.00	3" x 4"
	20.00	4" x 5"
	24.00	4" x 6"

Fig. 131. Dimensions of Standard Leaders

should be used, and not plan areas. These areas will then be divided by the proper factor selected from the table in Fig. 130 and the required areas of the leaders thus determined. By then consulting Fig. 131, which gives the areas of various standard leader sizes, the proper leaders of the desired type can be ascertained.

Fig. 130 gives the intensity of rainfall which would be expected to occur in twenty-three cities according to U. S. Weather Bureau records, and the corresponding amount of roof area which one square inch of leader area will drain during such storms. The latter are based on the common assumption that for an intensity of eight inches per hour, one sq. in. of leader will care for 150 sq. ft. of roof. The table is set up on three different bases. Column "A" is for conditions which may be exceeded on the average of once in five years, Column "B" for rainfalls which may be exceeded once in ten years, and Column "C" gives the maximum rainfalls yet recorded. As stated before, which column should be used in any given instance is a question of judgment for the designer to decide.

Example:

Suppose the problem is to design the leaders for a building in Boston which is to be 120 ft. by 80 ft. with a plain gable roof having a ridge down the center and a slope of 9″ to the foot. Assume further that there will be a leader at each corner and that it seems proper to allow for one overflow in ten years.

Solution:

If the slope is 9″ per ft., the roof area on each side of the ridge is 120′ by 50′, or 6000 sq. ft., and each leader would serve 3000 sq. ft.

From Column "B" of Fig. 130, opposite Boston, it is found that 200 sq. ft. is the amount of roof area which 1 sq. in. of leader will serve, and accordingly a leader having an area of 15 sq. ins. is required.

Now from Fig. 131 it is found that 5″ round or octagonal leaders are required, or that either 3¾″ x 5″ square corrugated or 4″ x 5″ plain rectangular leaders could be used.

GUTTER DESIGN

Residence Work

As is the case with leader design, judgment plays a large part in the design of gutters. The type of structure and the requirements as regards overflow have an important bearing in the matter. In work where occasional overflow of the gutters is not a serious matter, experience has proven certain more or less arbitrary rules to be entirely adequate. These are based partly on the size of the leaders which are first determined as outlined in the foregoing pages.

The best type of gutter has the minimum depth equal to half and the maximum depth not exceeding three-quarters of the width. Thus the width becomes the deciding factor in proportioning its size. There is no reason for a gutter deeper than three-quarters of the width except for ornamental purposes, and for practical reasons it is distinctly desirable to keep the gutter shallow. Assuming that this proportion is observed the gutter may be referred to by its width only.

The size of gutters depends upon:

(1) The number, size, and spacing of the outlets.

The gutter acts as a receiving channel to carry the water to the outlet. The slope of the gutter determines the flow toward the outlets.

(2) The slope of the roof.

A steep roof carries the water to the gutter faster than a flat one does.

(3) The style of gutter used.

Some gutters are not effective for their full depth and width. In proportioning gutters proper consideration of the available area is essential.

(4) A gutter smaller than 4″ wide should be avoided.

In ordinary practice 4″ gutters are seldom used for they are difficult to solder and increase the labor cost. The gutter may be the same size as the leader it serves, but, of course, can not be smaller.

(5) Half-round gutters are economical and properly proportioned.

This type uses a minimum of material and insures a proper ratio of width to depth.

(6) A minimum pitch of 1/16 of an inch per foot should be provided.

Less than this will not provide for proper flow of water in the gutter.

Based on the above, safe rules for determining the size of gutters for ordinary work are:

(1) If spacing of leaders is 50′ or less, use a gutter the same size as the leader, but not less than 4″.

(2) If spacing of leaders is more than 50′, add 1″ to the leader diameter for every 20′ (or fraction) additional spacing on peaked roofs, and add 1″ for every additional 30′ of gutter length for flat roofs.

Examples:

1. A 40′ gutter serves a 3″ leader. The gutter should be 4″.

2. A 75′ gutter serves a 4″ leader on a steep roof. The gutter width is 6″.

3. A 75′ gutter serves a 4″ leader on a flat roof. The gutter width should be 5″.

Monumental Buildings

This title is here used to refer to all installations where the conditions are such as to require very adequate and liberal design in order to insure against any possibility of gutter overflow. Such conditions exist for the most part in special cases of monumental structures where the arrangement is such that a single overflow is to be avoided as having serious consequences.

For such designs the use of the formulae (or the charts which are based on them) which follow are recommended. These are empirical formulae derived from the results of actual tests carried out on level gutters in the laboratory at the U. S. Bureau of Standards in Washington. By using them, much more liberal designs are obtained, and ones which are believed to be amply safe for important work. These formulae are:

For semi-circular gutters: $w = 1.3\ Q^{2/5}$
For rectangular gutters: $w = 0.481\ m^{-4/7}\ l^{3/28}\ Q^{5/14}$
where, w = width of gutter in feet
m = depth/width
l = length of gutter in feet
Q = total gutter inflow (cu. ft./sec.)

The charts of Figs. 132, 133A and 133B have been plotted from these formulae so that the gutter width may be read directly in inches in terms of rainfall intensity and tributary roof area.

Example 1:

A semi-circular level gutter is required to drain a roof 20′ x 40′, located in Memphis.

Solution:

From Fig. 130, third column, a maximum rainfall intensity of 10″ per hour is given for Memphis. The roof area is 800 sq. ft. On the graph of Fig. 132 find 800 on the bottom scale, pass vertically to the horizontal line representing a rainfall of 10″ per hour. The intersection falls nearly on the line marked 8″ which, accordingly, is the width of the gutter required. If the intersection falls between two sizes, the larger one should, of course, be used.

Example 2:

A roof area 40′ long by 20′ wide is to be drained by a rectangular level gutter, the depth of the gutter being half of the width. The building is located in Atlanta.

Solution:

From the third column of Fig. 130 the maximum intensity of rainfall for Atlanta is found to be 9″ per hour. From the proportions of the gutter, $m = 0.5$ (depth divided by width). On the chart Fig. 133A find $l = 40$. Pass vertically to the heavy line representing $m = .5$, and horizontally left, read $N = 23.3$.

The rainfall intensity ($I = 9$) times the area ($A = 800$) gives $IA = 7200$. On the chart Fig. 133B, locate $N = 23.3$ at the bottom scale, and pass vertically to the horizontal line representing $IA = 7200$. The point of intersection falls between the lines representing widths of 6″ and 7″. The required gutter width is, therefore, 7″.

The required sizes of level gutters of other than semi-circular or rectangular shapes can be determined approximately by finding the semi-circle or rectangle of the same area which most closely fits the irregular cross-section. This can be done by drawing the gutter of required shape to any convenient scale and making the fit graphically so that the areas of excess and shortage will be equal. A trapezoidal shape of depth equal to one-half the width is closely fitted by a semi-circle. A molded gutter can usually be well approximated by a rectangle. This method of approximation was checked experimentally in laboratory tests, and the discrepancies found to be very small.

OUTLET DESIGN

The design of outlets is of great importance, for if they are not properly proportioned the horizontal gutter flow will not be adequately transmitted to the vertical leaders. Although the latter may be of sufficient capacity, that will be of no avail in preventing overflow if the outlets do not permit the drainage to enter the leaders as fast as it arrives.

It has been found from experience and tests that outlets should be elliptical or rectangular in plan with the larger dimension in the direction of the gutter flow. For semi-circular gutters, outlets should be as long as the gutter width and two-thirds as wide. For rectangular gutters 6″ wide or less, the outlet should be about 2″ less in width than the gutter and of the same length as the gutter width. For larger gutters it is safer to make the outlet the full gutter width and about one and a half times as long.

With the area of the top of the outlet (in the gutter bottom) determined as just outlined, it is tapered down to the size of the leader, so that it is shaped like the frustrum of a cone or pyramid, according to the formula:

$$h = \frac{A^2}{630\ d^4}$$

where, h = inches of head on the leader inlet, (i.e. depth of outlet)
A = sq. ft. of tributary roof area
d = inches of leader diameter

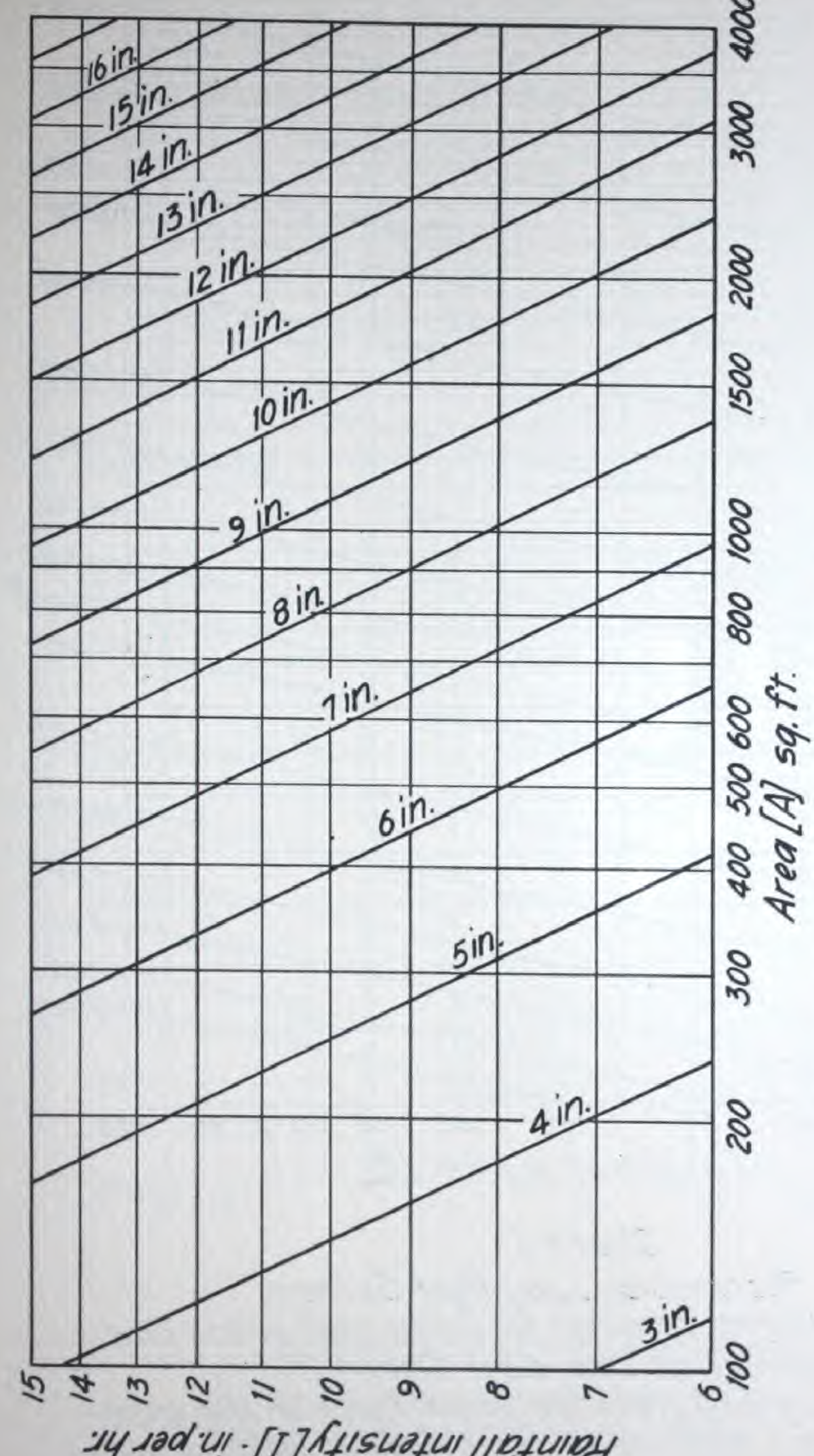
Example:

Taking the example on page 99, the roof area was found to be 3,000 sq. ft. and 5″ round leaders were required.

Each leader serves 60′ of gutter, so from the rules on page 99 a 6″ half-round gutter is required.

From the discussion just above, the top of the outlet should be 6″ long and 4″ wide, and its depth should be:

$$h = \frac{9{,}000{,}000}{630 \times 625} = 23''$$



Semi-circular Level Roof Gutters

Width of gutter required for given roof areas and rainfall intensities.

Fig. 132

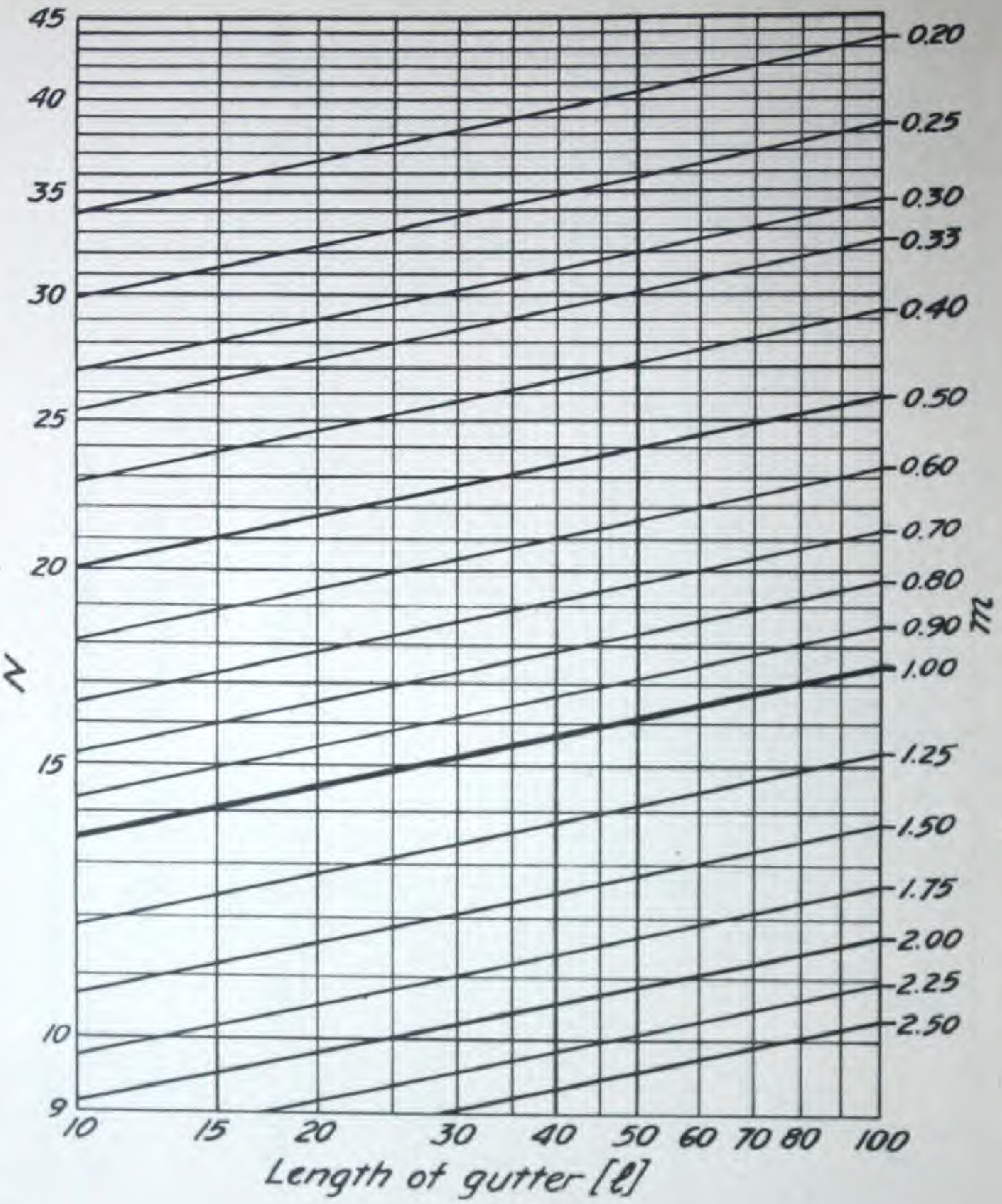


Chart 1
Rectangular Level Roof Gutters
Width of Gutter required for given roof areas and rainfall intensities. See also Chart 2.
The quantity [m] gives the proportions of the cross-section. m = depth of gutter divided by width of gutter.

Fig. 133A

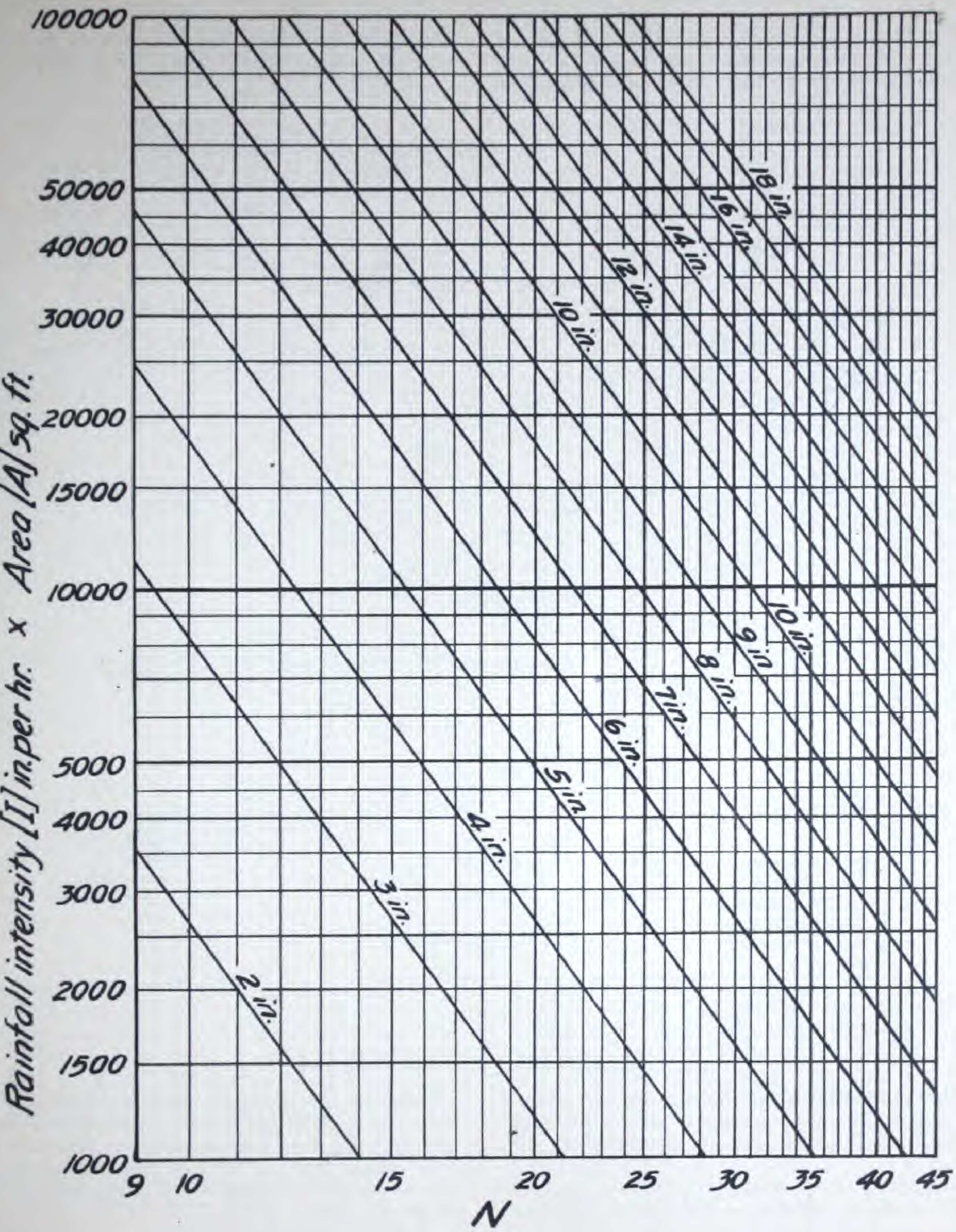


Chart 2

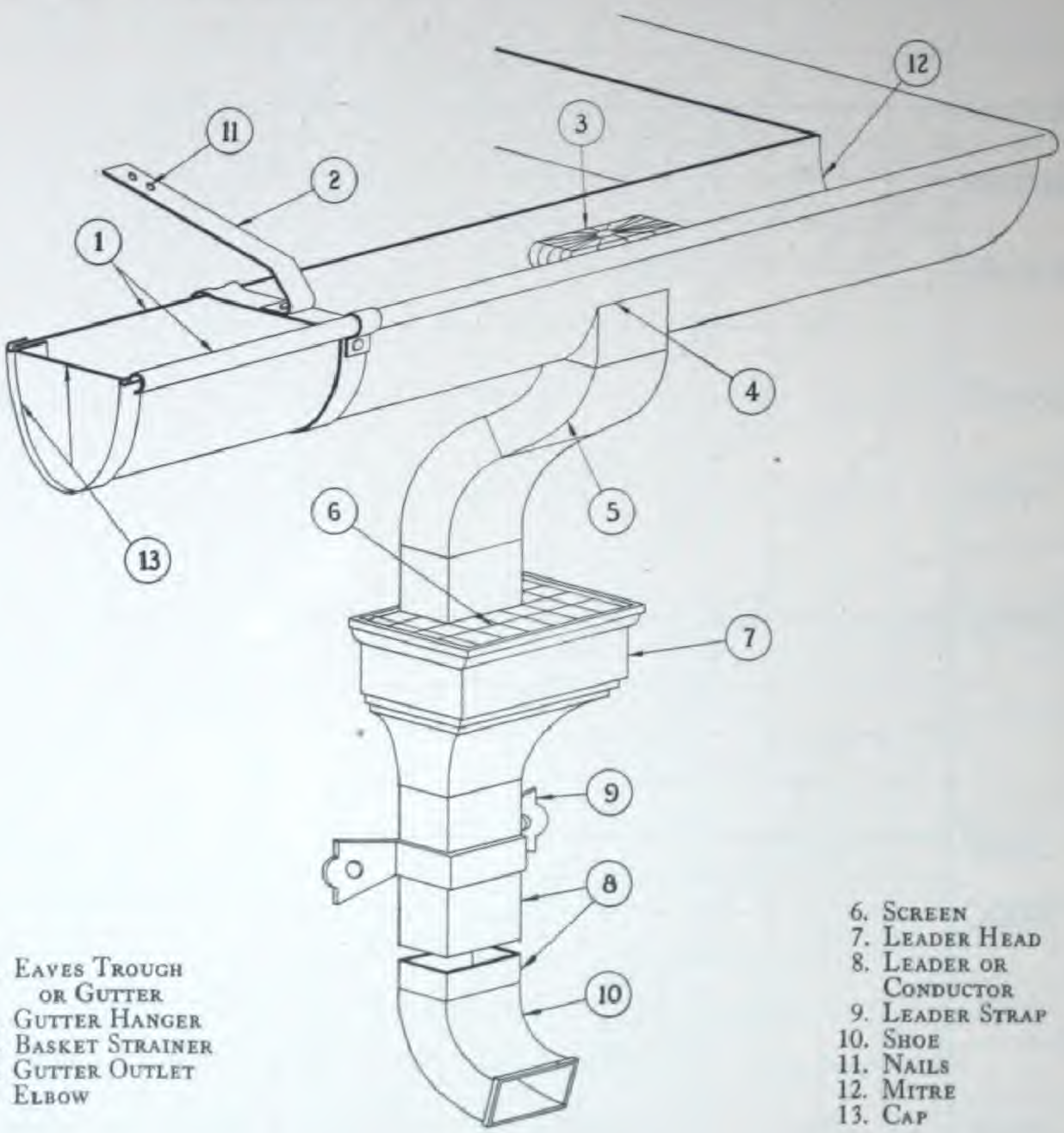
Rectangular Level Roof Gutters

Width of gutter required for given roof areas and raintall intensities.

Fig. 133B

GUTTERS, LEADERS & ACCESSORIES

In Fig. 134 are shown the various parts of gutters, leaders and accessories as generally made up and stocked by manufacturers. While there is some difference in nomenclature throughout the country, manufacturers and the trade in general use the designations given.



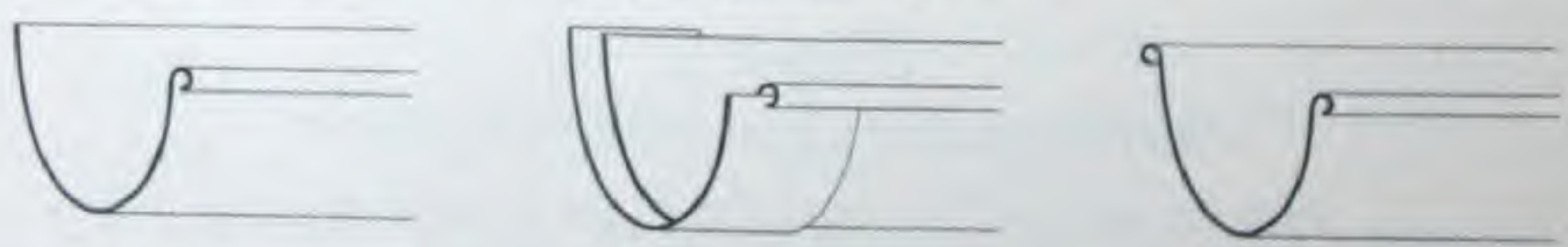
1. Eaves Trough or Gutter
2. Gutter Hanger
3. Basket Strainer
4. Gutter Outlet
5. Elbow
6. Screen
7. Leader Head
8. Leader or Conductor
9. Leader Strap
10. Shoe
11. Nails
12. Mitre
13. Cap

Fig. 134

HALF-ROUND EAVES TROUGH

Molded gutters, including half-round, are made in several designs. The most commonly used is the Single-Bead, half-round Eaves Trough illustrated in Fig. 135A and B.

This type of gutter is stocked throughout the country and is carried in sizes up to 6″ by practically every sheet metal contractor. Sizes above 6″ are not in common use, as buildings requiring gutters of a larger size usually have them built-in or made a part of the cornice. Sizes up to 10″ may be had and are stocked in the warehouses of large distributing companies in the principal cities.



A — Single-Bead Lap Joint

B — Single-Bead Slip Joint

C — Double-Bead Lap Joint

Fig. 135. Half-Round Gutters

Fig. 135C shows the Double-Bead Eaves Trough. This, as may be noted from its contour, is somewhat stiffer than the Single-Bead. On account of this stiffness it is possible to place the hangers slightly farther apart than when the Single-Bead is used. However, it is much more difficult to erect, as the inside bead makes it difficult to line it against the roof edge, and to secure the hanger. It also costs more than the Single-Bead. That the Single Bead is in every respect satisfactory is indicated by the fact that there is so little call for the Double-Bead that it is not stocked and has to be made up to order.

Half-round Eaves Trough is made in both lap- and slip-joint style (see Fig. 135A and B). The slip joints are used to provide expansion and contraction in long runs of gutters. They are set about every five lengths or 50′ apart, the joints between being lapped and soldered. The slip joint is not soldered. In some localities the practice is to lap the lengths about 3″ and use no solder or slip joints. This practice is satisfactory where there is considerable slope to the gutter and where there is no danger of leaves, etc., stopping the flow toward the outlet. It is obvious that all joints in gutters should be made in the direction of the flow.

MOLDED COPPER GUTTERS

Style C

5″ wide, 3½″ deep, 12″ girth
6″ " 4¼″ " 14″ "
7″ " 4½″ " 16″ "

Style D

6″ wide, 4″ deep, 15″ girth
7″ " 5″ " 18″ "
8″ " 5¾″ " 20″ "

Style E

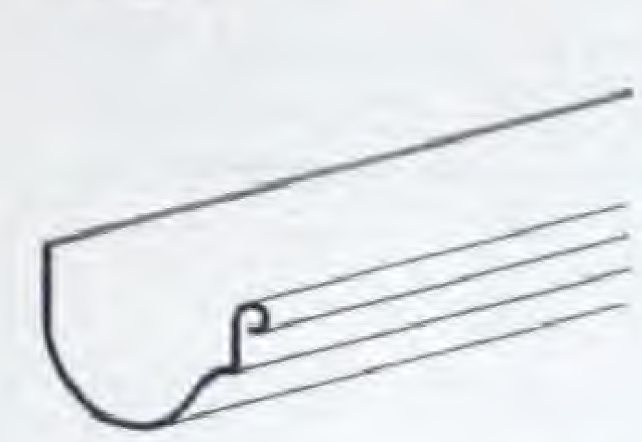
6″ wide, 4½″ deep, 15″ girth
7″ " 5½″ " 18″ "
8″ " 7″ " 22″ "

Style F

6″ wide, 5½″ deep, 18″ girth
7″ " 5¾″ " 20″ "
8″ " 6″ " 22″ "

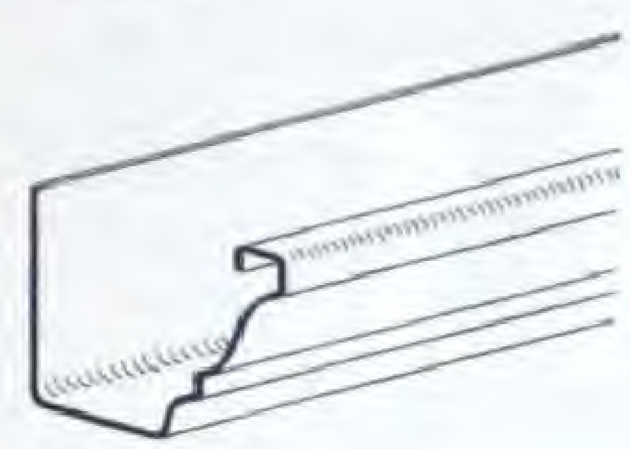
Style G

6″ wide, 5½″ deep, 18″ girth
7″ " 6½″ " 20″ "
8″ " 7″ " 22″ "



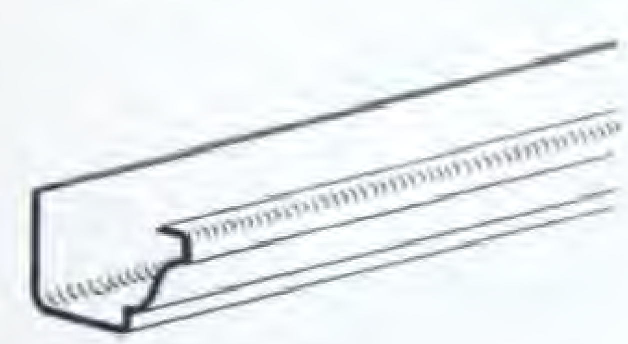
Style H

6″ wide, 4″ deep, 14″ girth
7″ " 4¾″ " 16″ "
8″ " 5½″ " 18″ "



Style J

6″ wide, 5¾″ deep, 18″ girth
7″ " 6½″ " 20″ "
9″ " 8″ " 24″ "



Style K

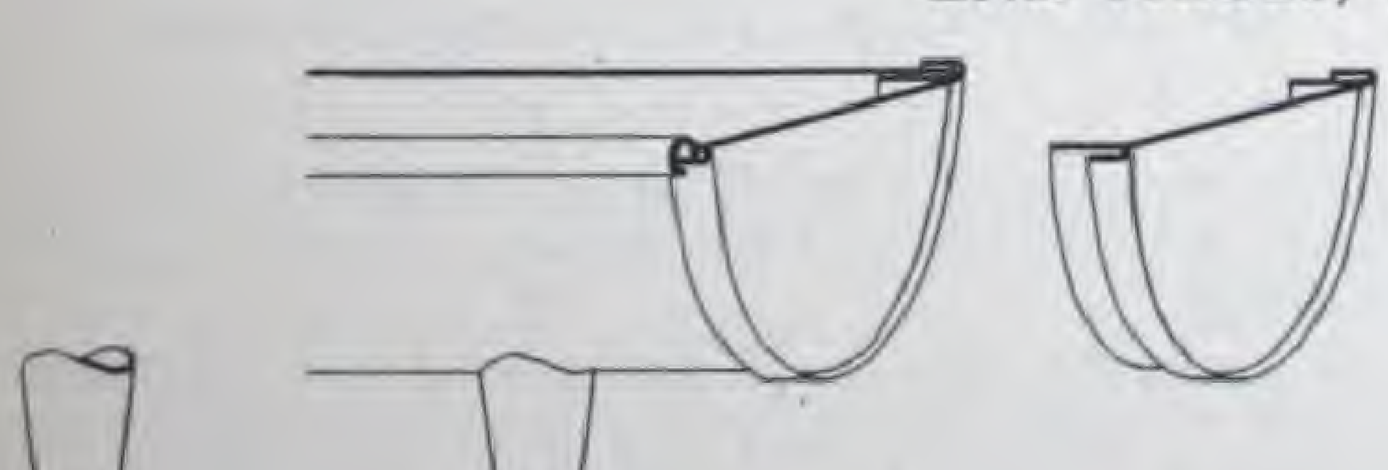
5″ wide, 2¾″ deep, 10″ girth
5¼″ " 3½″ " 12″ "
5½″ " 4¼″ " 14″ "

Fig. 136. Molded Gutters

Molded gutters of a quite different style are shown in Fig. 136. As the popularity of these does not warrant their being stocked, they are usually made up to order and prices may be had on application only. A study of the figures indicates why these styles do not sell as well as the Single-Bead Eaves Trough. They require more metal for the same effective area.

A 5″ half-round Single-Bead Eaves Trough has a girth of 10″. Style C gutter, 5″ wide, has a girth of 12″, 20% more. A 6″ half-round Single-Bead Eaves Trough has a girth of 12¼″. Styles C and H gutters have a 14″ girth; style D, 15″; styles G and J, 18″. The increase in the amount of copper varies from 14 to 46%.

END PIECES, CAPS AND OUTLETS



A Outlet — B Assembly — C Cap

Fig. 137

Fig. 137 shows the usual accessories for half-round Eaves-Trough which are carried in stock or can be quickly supplied. It is recommended that these pieces be used wherever possible as they are factory made and are generally of stronger construction than those made in the field.

MITRES

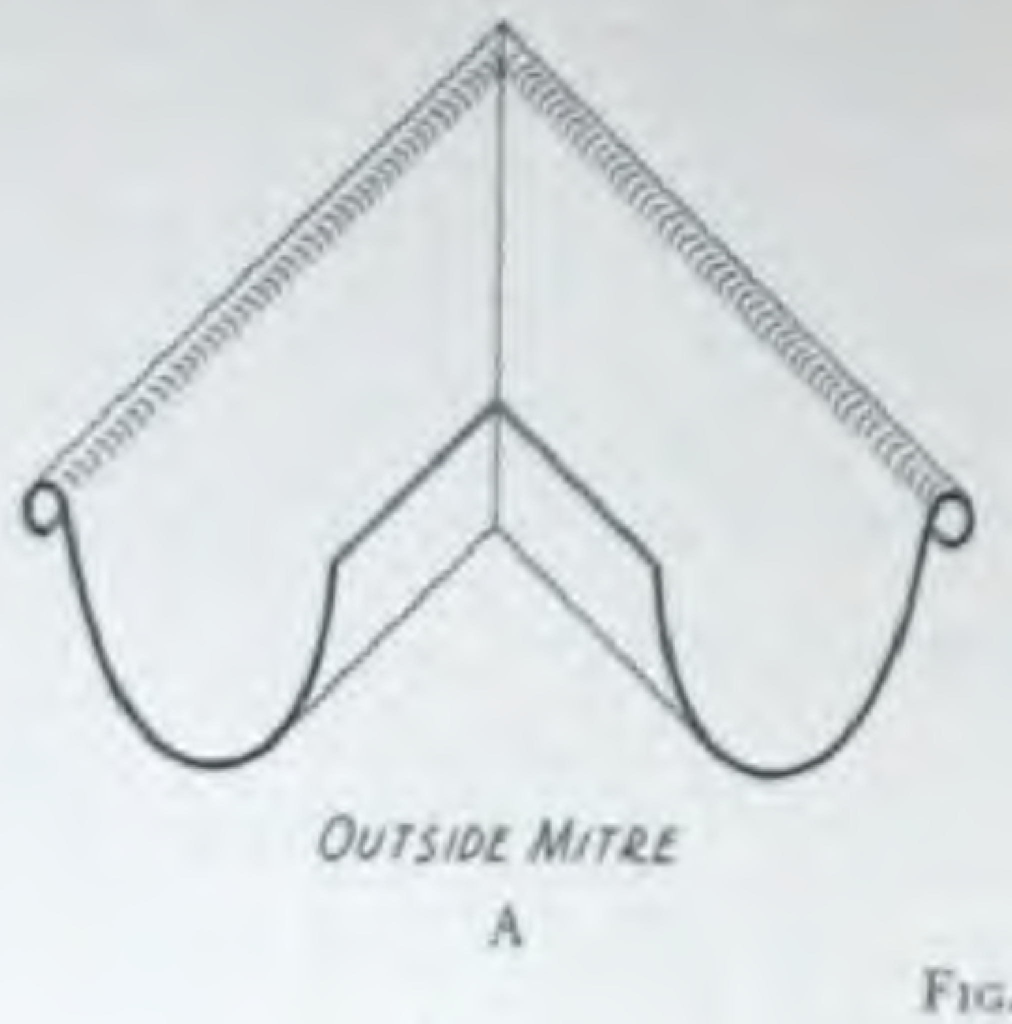


FIG. 138

In Fig. 138A and B are shown single-bead half round outside and inside mitres. They are regularly stocked in 16-oz. copper and are also available with the double-bead. In ordering, the bead should be stated as well as whether "inside" or "outside" mitres are wanted; if slip joints, whether "rights" or "lefts".

GUTTER HANGERS

There are many kinds of copper hangers on the market, most of which are satisfactory for the special conditions for which they are made. Several varieties, but by no means a complete selection of those available, are illustrated in Figs. 139, 140 and 141.

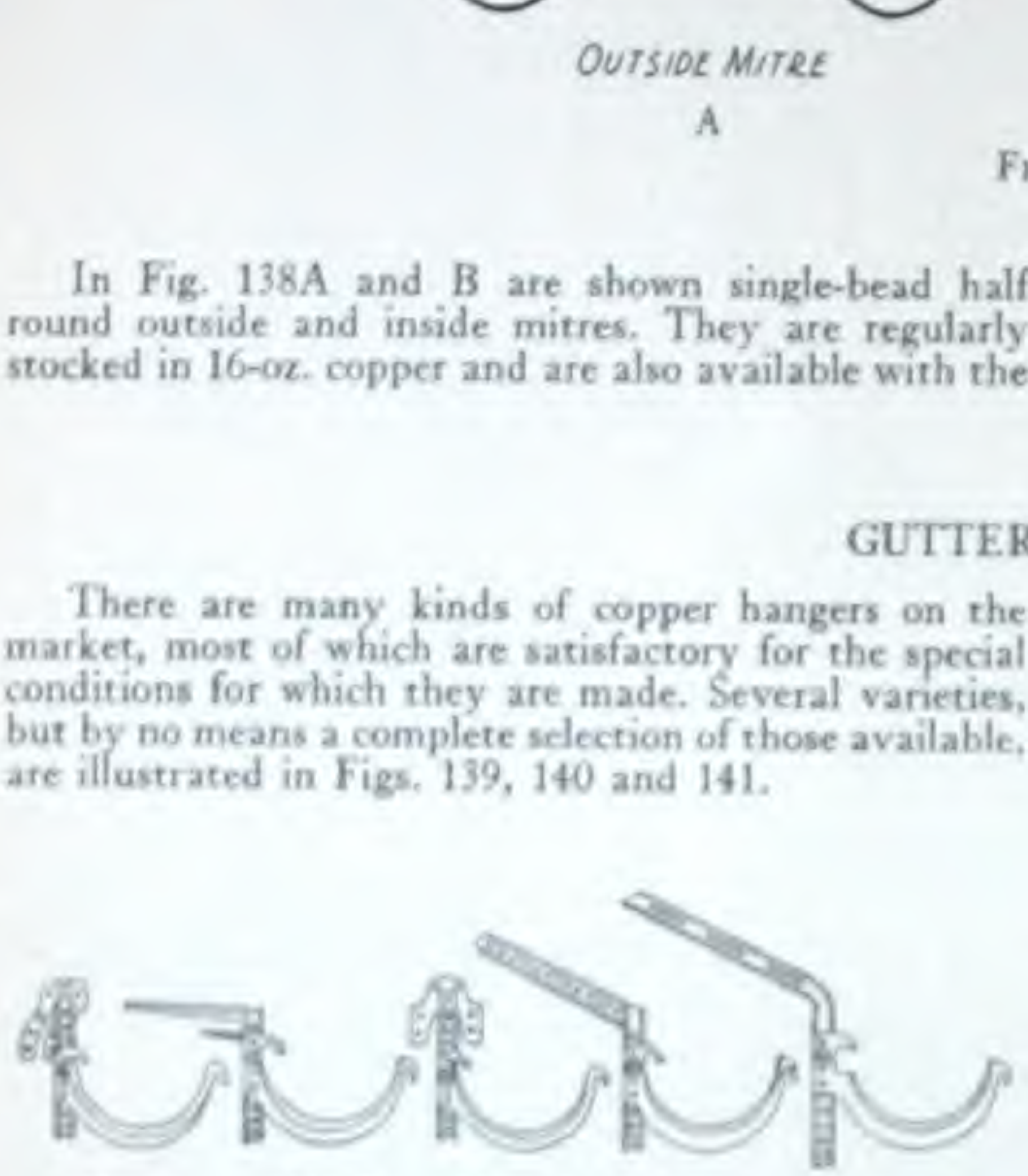


FIG. 139. BRONZE AND COPPER HANGERS SHANK AND CIRCLE TYPE

Fig. 139 illustrates some of the bronze and copper shank and circle type of hangers. These may be made of either cast or wrought metal. They can be adjusted to give the gutter the necessary pitch by attaching the circle part to the shank at different heights. The shank is normally attached when the building is erected and the gutters hung later, after the painting is done, thus avoiding the chance of damage to the gutters by the painters' scaffolding and ladders.

FIG. 140. WROUGHT COPPER STRAP HANGERS

Two types of wrought hanger are shown in Fig. 140 and two other types of wrought hanger in Fig. 141. With a single-bead gutter it is usual to use some type of hanger which encircles the gutter, whereas with a double-bead, as shown on the right of Fig. 141, it is possible to have a hanger which is attached only to the two beads and has no part going under the gutter proper. These wrought hangers are made from sturdy material and are moderately priced. They are used extensively. Strap hangers are simple to apply and lend themselves to almost every type of eave.

FIG. 141. WROUGHT COPPER STRAP HANGERS

The spacing of cast or strap hangers should not exceed 36" and even closer spacing may be used to advantage.

In specifying the shank and circle type of hangers, be sure to give the circle size (corresponding to the gutter size, e.g. 4", 5", etc.) as well as the number of the type of shank selected (e.g. No. 6, No. 7, No. 10, etc. See Fig. 139).

LEADERS, LEADER HEADS AND STRAPS

As may be seen in Fig. 142 leaders or conductors are made in four different shapes. Special designs may also be had upon aplication. Plain round leaders are not generally stocked by manufacturers and jobbers. They are not generally used because, it is stated, they do not resist freezing as well as do the corrugated ones. Moreover the latter are more pleasing in appearance when in place than are the plain ones. Sixteen ounce leaders are regularly furnished in 10′ lengths.

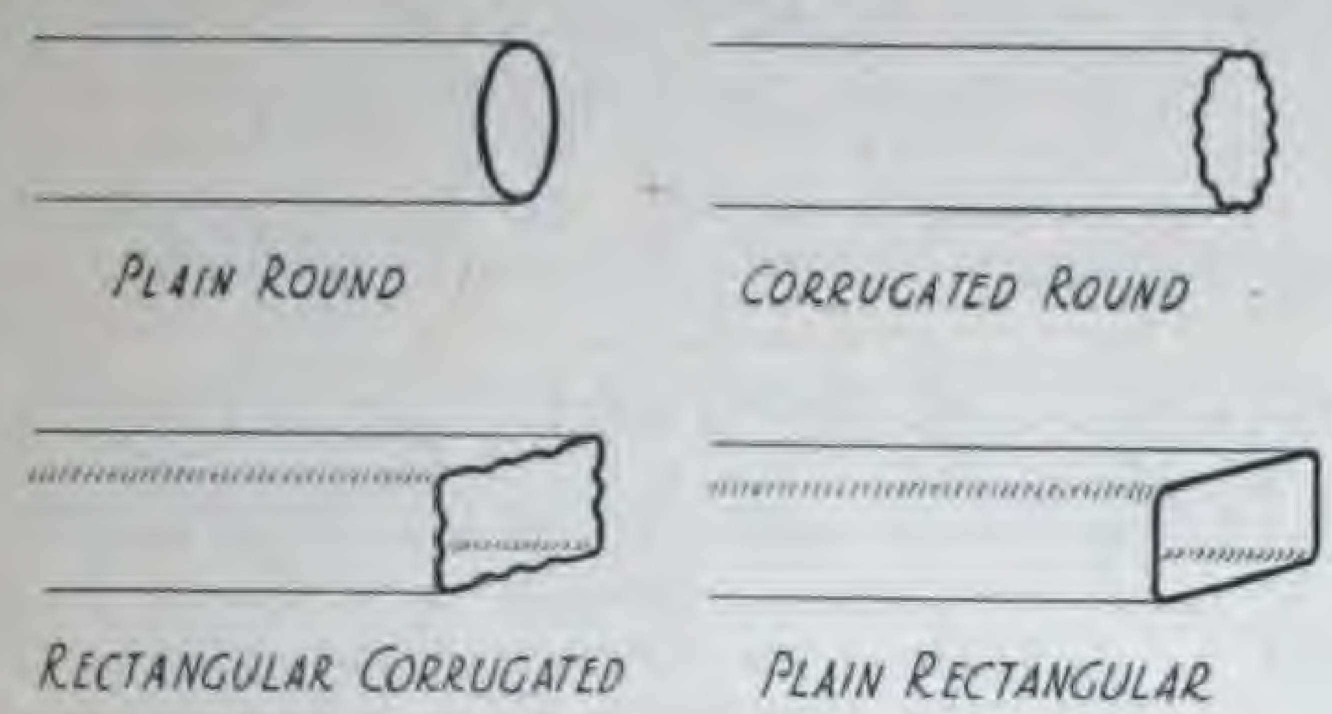


Fig. 142. Standard Leaders

In Fig. 143 are illustrated two typical ornamental leader heads, of stock design. A number of other stock designs are readily available or special designs can be quickly made up, in which case the number required largely controls the cost of manufacture.

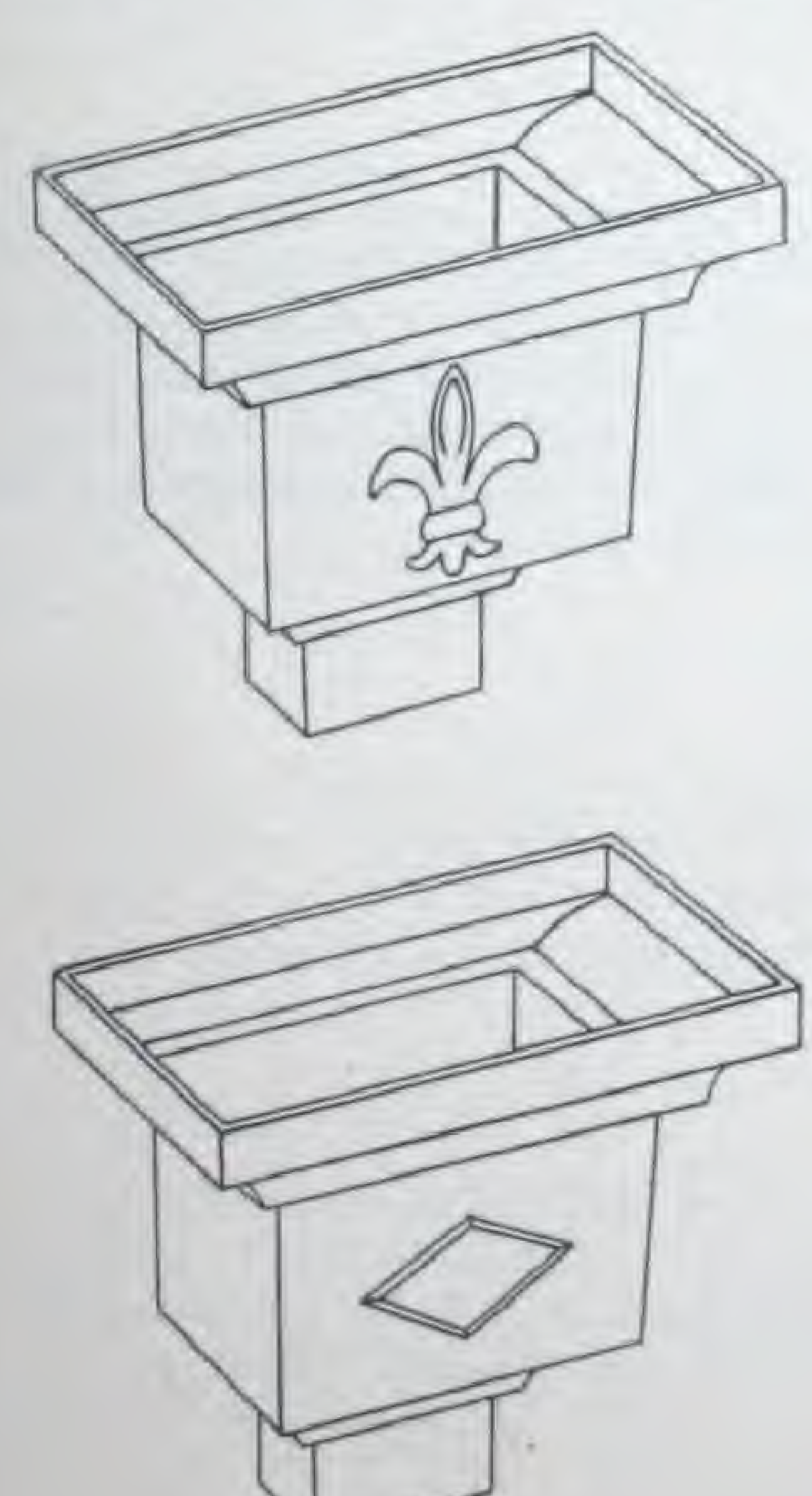


Fig. 143. Leader Heads

Two typical designs of leader straps regularly carried in stock by sheet metal supply houses are shown in Fig. 144. At the top and bottom of the illustration are shown the straps as they are supplied, flat. In the center the same straps applied to rectangular leaders. The same straps could be used for other types such as the round or corrugated. Many other stock designs are available from which a selection may be made.

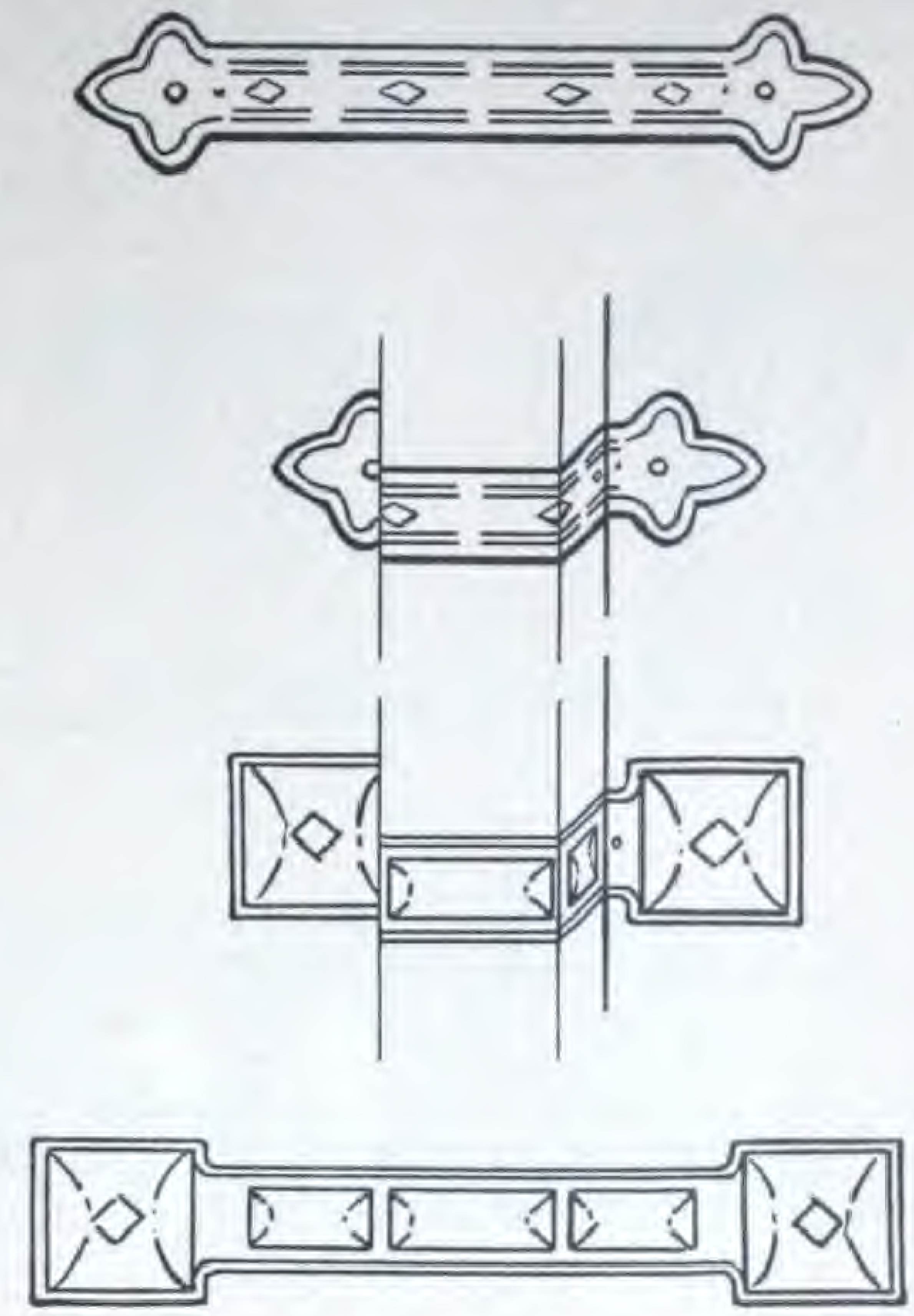


Fig. 144. Leader Straps

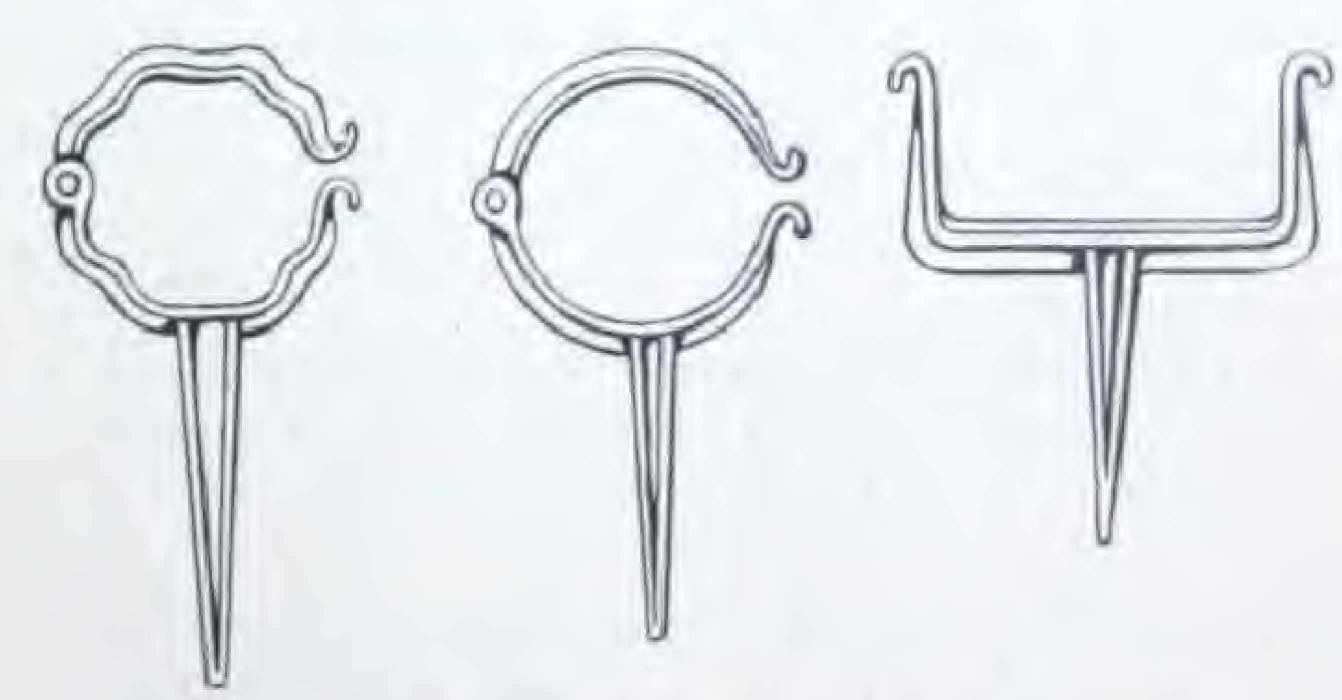


Fig. 145. Cast Bronze Leader Hooks

Fig. 145 illustrates three common types of leader hooks. These can also be obtained in two pieces—the clasp part separate from the shank. Shanks are available in different lengths, designed either for wood or brick drive. These leader hooks are driven into the wall before the leader is placed. Leader hooks and straps should not be more than 6 feet apart.

COPPER ELBOWS AND SHOES

Copper elbows and shoes are stock leader accessories, and are illustrated in Fig. 146. They are made in many styles and shapes to fit every condition encountered in building. The use of regularly formed pieces such as these is recommended as far preferable to the all too-often-used expedient of soldering straight pieces of leader at angles, to make turns. The latter construction is not only unsightly but is subject to rapid erosion.

FIG. 146. COPPER ELBOWS AND SHOE

WIRE BASKET STRAINERS

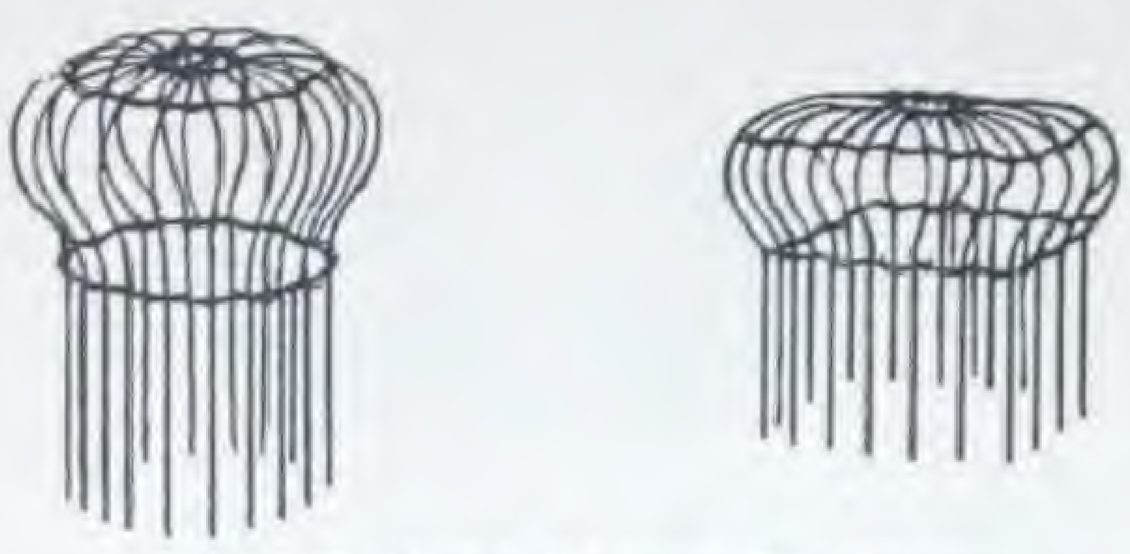


FIG. 147. WIRE BASKET STRAINERS

Wire basket strainers of stock design and as generally carried by jobbers and sheet metal contractors are shown in Fig. 147. Strainers of heavier design and wire can be made up quickly to specification. Every outlet should be provided with strainers. Especially is this essential when the leaders are small or have any elbows, etc., where leaves are likely to stick and clog the leader. For large installations heavier cast brass strainers should be used as illustrated in Figs. 109, 111 and 112.

SNOW GUARDS

Snow guards for Copper roofs are of two general types. The simpler form is made of about No. 9 B. & S. gage copper or copper alloy wire, formed as shown in in Fig. 148, to stand about 2″ high on the roof. These are soldered to the roof sheets at intervals, usually towards the bottom of the slope only. Spacing depends on slope and local weather conditions.

FIG. 148. WIRE SNOW GUARDS

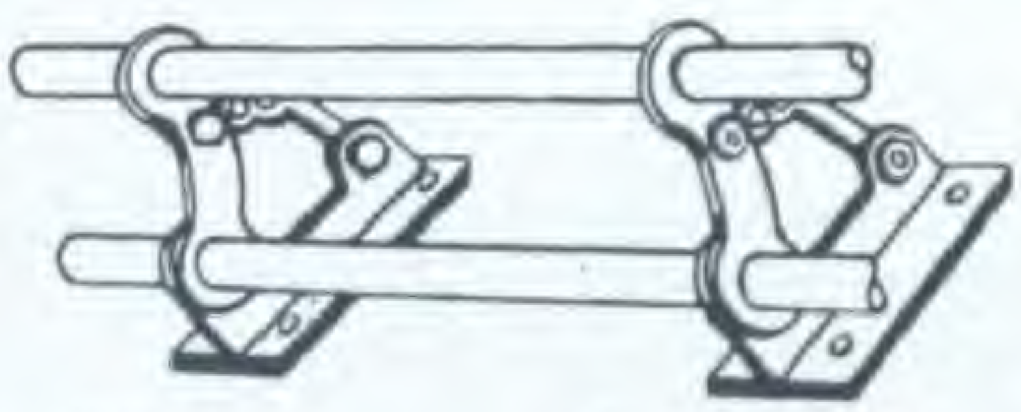


FIG. 149. BRACKET AND PIPE SNOW GUARDS

For large buildings a more substantial type, such as illustrated in Fig. 149, is often used. The cast bronze brackets can be adjusted as required and are bolted through to the roof structure, using lead washers. Brass pipe runs across between brackets. Both these types and others can readily be obtained through any sheet metal and roofing supply house.

SECTION V—SPECIFICATIONS

It would hardly seem necessary to stress the importance of proper and adequate specifications. The proper application of all materials in building construction is essential and this applies to copper as well as to the other materials. The specifications are the means of accomplishing this, and very often they are too meagre. They should be sufficiently detailed to cover every point of application, materials and workmanship accurately, and to permit of only the one proper interpretation of the detailed drawings.

As a safeguard to all the parties involved completeness in the specifications will go a long way toward insuring uniform bids and preventing unscrupulous contractors from taking advantage of inadequate specifications to underbid reliable firms by cutting on material and workmanship.

It is further urged that the specifications or the general contractors ask sheet metal contractors to include in their bids the total number of square feet and total weight of the copper to be used. This will largely eliminate misinterpretation of specifications. The weight of metal can readily be compared with the number of square feet within the tolerance limits, to ascertain that the correct weight sheets are to be used. The number of square feet offers an easy way to compare the different contractors' interpretations of the specifications.

STANDARD SPECIFICATIONS FOR SHEET-COPPER WORK

(Covering in detail Roofing, Flashings, Roof-Drainage, etc.)

Notes

(a) It should be noted that, wherever in this long specification Alternate Methods of doing work are described, they are designated by letter in order of recommended practice. In every case the first listed (letter A) describes recommended best practice.

(b) Different Methods for different kinds of construction are collected under one general heading and sub-numbered 1, 2, 3, etc.

(c) The arrangement of subjects has been made to agree, as nearly as possible, with the usual arrangement of sheet-metal specifications for the average building.

(d) When it is desired to write a short specification to cover all the Sheet Copper Work on a building Item 1 alone may be used. There should then be a definite understanding between the contracting parties about Alternate Methods.

1. Sheet-Copper Work.

Unless otherwise particularly specified, all sheet-metal work and all material and labor in connection therewith shall be furnished and performed in strict compliance with the recommended practice and Standard Specifications for Sheet-Copper Work of the Copper & Brass Research Association, 420 Lexington Ave., New York.

2. General.

The General Conditions of the contract are hereby made a part of the contract and this contractor shall examine these General Conditions and thoroughly acquaint himself with all the requirements therein contained.

3. Scope of Work.

Except as otherwise specified this contract includes the furnishing of all labor and materials necessary to complete in every respect, in accordance with the best practice, all the Sheet-Copper work of every description for this building.

4. Guarantee.

Before final payment the contractor shall give to the owner a written guarantee which shall specify the kind, weight and manufacturer of the materials used, and shall guarantee his work free from all defects of workmanship for a period of two years after completion and shall make good all defects and all damage to the building from leaks during that time. If so directed by the architect this contractor shall execute a proper guarantee bond.

5. Contractor to Examine Surfaces.

This contractor shall carefully examine all surfaces prepared for flashings, etc., by other trades, shall point out all defects, and shall see that the necessary corrections are made before proceeding with his work.

This contractor shall arrange his work so as to co-operate at all times with other trades and prevent delay or damage to other work.

6. Precautions against Damage during Construction.

During construction care shall be taken to prevent damage to sheet-copper work in place by walking or placing heavy materials thereon. As soon as soldering is done, the work shall be thoroughly cleaned. Toward completion, all damaged work shall be repaired, shall have all stains and debris removed, and shall be left in perfect condition.

7. Preparation of Surfaces. (Other Contractors.)

All surfaces to receive flashings shall be made smooth and even, and free from all small projections or hollows, and all nail heads shall be set.

8. Building Paper.

Before laying copper all surfaces shall be covered with building paper or roofing felt of approved quality, weighing not less than 6 pounds per 100 square feet (i.e. 30 pounds per standard roll of 500 square feet). Paper shall lap 2 inches and be nailed with large flat-head copper nails.

9. Sheathing. (**Carpenters' Specification.**)

All sheathing upon which sheet copper is to be laid shall be of straight, unwarped boards, free from splits and knot holes. All joints shall be true and even. All nail heads shall be set. All uneven edges of boards shall be smoothed off to give a firm, even surface.

Notice shall be given to the roofing contractor when the sheathing is laid and an inspection shall be made by him. All defects observed at this inspection shall be corrected promptly.

10. Wood Sheathing.

All wood sheathing shall be absolutely dry and sound when copper is applied. The lumber shall be (**A**) kiln-dried; (**B**) air-dried.

11. Concrete. (**Masons' Specification.**)

All concrete surfaces to be covered with copper shall be made smooth and even with a wash of neat cement. Where cinders have been used in the concrete it shall be painted with two heavy coats of asphalt paint.

Where required, provision shall be made for securing copper work by means of (**1**) *nailing into* (**A**) *nailing concrete;* (**B**) *embedded wooden battens or* (**2**) *expansion bolts.*

12. Gypsum. (**Manufacturers' Specifications.**)

Gypsum surfaces to receive sheet copper shall be well-laid, smooth and even. Where nailing is required the gypsum shall be provided of sufficient thickness to allow a 2-inch penetration of copper alloy nails.

13. Miscellaneous Laying Surfaces (**Manufacturers' or Masons' Specification**).

Where copper is to be laid on or against terra-cotta, stone, brick or stucco the surfaces shall be made smooth and even with a wash of neat cement or two coats of heavy asphalt paint. Required provision shall be made for proper fastening.

14. Sheet Copper.

Where shown on drawings or described in these specifications all sheet-metal shall be of copper conforming to the Standard Specifications of the American Society for Testing Materials, and plainly marked with the manufacturers' name and the weight.

15. Soft (**Roofing Temper**) **Copper. Hard** (**Cornice Temper**) **Copper.**

Except as otherwise specified, all copper throughout the work shall be of 16-oz., soft (roofing temper) copper sheets.

All leaders, eaves troughs, molded hanging gutters, and other formed parts as specified, shall be of 16-oz., hard (cornice temper) copper.

16. Lead-Coated Copper.

Except as otherwise specified all lead-coated copper shall consist of 16-oz. soft (roofing temper) copper sheets coated with lead. The exact weight, texture, and tone of the lead coating on each side of the sheet shall be as specified by the architect, in accordance with Specification B-101 of the American Society for Testing Materials.

17. Crimped Copper.

Where specified copper sheets shall be used which have been crimped by passage through heavy rolls to form ridges about 7/32-inch center to center in the direction of the short dimension.

18. Corrugated Copper.

Where called for on the drawings corrugated copper of the form and gage specified shall be used. The form and size of the corrugations shall be clearly and completely defined by means of dimensions.

19. Tin.

All tin used for tinning seams for soldering, etc., shall be best grade, pure metal.

20. Solder.

All solder shall be of the best grade, equal to Specification B-32 of the American Society for Testing Materials, and shall be composed of one-half pig lead and one-half block tin (new metals).

21. Flux.

Rosin shall be used as a flux.

In exceptional cases where acid flux must be used it shall be thoroughly "killed" with zinc before being applied to the copper. After soldering with acid flux the entire work shall be thoroughly washed with a solution of soap and 5% to 10% washing soda.

22. Tinning.

The edges of all sheets to be soldered shall be tinned 1½" on both sides with pure tin or solder. Rosin shall be used as a flux.

23. Soldering-Coppers.

All soldering shall be done with heavy soldering coppers of blunt design, properly tinned before use. They shall weigh not less than 6 lbs. to the pair. For flat seam work on decks, in gutters, etc., they shall weigh not less than 10 lbs. to the pair.

24. Soldering.

Soldering shall be done slowly with well-heated coppers so as thoroughly to heat the seam and fill it completely with the solder.

25. Seams.

Standing seams shall finish not less than 1″ high unless particularly specified otherwise.

Flat-lock seams shall finish not less than ½″ wide.

Lap seams, where soldered and subject to stress, shall finish not less than 1″ wide.

Lap seams, where soldered and not subject to stress, shall finish not less than ½″ wide.

Lap seams not soldered shall lap according to the pitch but not less than 3″.

Double or copper-lock seams shall finish not less than ½″ wide.

All flat and lap seams shall be made in the direction of the flow.

26. Loose-Lock Seams.

Loose-lock seams shall be provided as specified and shall be so formed and located as to preclude leakage.

27. Exposed Edges.

The exposed edges of all flashings shall be doubled back ½″ in such manner as to conceal them from view and to provide stiffness.

28. Expansion Joints.

Expansion joints of the size and type indicated shall be provided as called for in the drawings.

Such joints shall be placed:

(**-1**) Every 25′ to 50′ in continuous copper lined gutters, cornices, etc.

(**-2**) In conjunction with building expansion joints.

29. White Lead.

Where specified seams shall be caulked with white lead paste made up of basic lead carbonate, conforming to specification D81-34 of the American Society for Testing Materials, and boiled linseed oil. The oil shall make up 8% of the paste which shall be smooth, free from lumps, and of a putty-like consistency.

30. Nails and Fastenings.

All nails, rivets, screws and similar fastenings shall be of best grade hard copper or copper alloy.

Nails for wood sheathing and nailing concrete shall be wire nails not less than No. 12 gage and not less than ⅞″ long.

Nails for precast or poured gypsum shall be not less than No. 9 gage and not less than 2″ long.

31. Cleating and Fastening.

All sheets over 12″ wide shall be fastened by cleats 2″ wide and about 3″ long, spaced as specified elsewhere. They shall be secured to the roof by two nails set about ¾″ from the end and shall have the end turned back ½″ over the nail heads. The free end of the cleat shall be turned over to engage the edge of the sheet and shall be locked into the seam. Where seams are soldered cleats shall be tinned. Except as otherwise specified cleats shall be spaced not more than 12″ apart.

Sheets less than 12″ wide shall be secured by nails spaced as specified for different types of flashings.

Where flashings are nailed the nailing shall be restricted to one edge only. Nails shall be near the edge and shall be evenly spaced not more than 4″ apart, unless otherwise specified.

Where copper is laid on concrete or gypsum roof slabs the roofing contractor shall prepare detailed instructions, with drawings, etc., for locating all fastenings for cleats, edge- and eaves-strips, flashings, etc.

32. Fastenings for Copper Roofing. (**Masons' Specification.**)

In all concrete or gypsum roof slabs which are to be covered with copper roofing or flashing, set fastenings for cleats, edge- and eaves-strips, etc., as located by the sheet-metal contractor. Fastenings shall consist of (**1**) *2″ x 2″ nailing strips placed in the roof slab flush with surface;* (**2**) *wood grounds placed in the roof slab at eaves, etc.;* (**3**) *expansion inserts to receive nails or screws.*

Before the roof slabs are poured this contractor shall obtain from the sheet-metal contractor complete instructions, with drawings, for locating fastenings.

33. Ribbed (Batten) Seam Roofing.

Wood or copper alloy ribs of the shape and dimensions indicated shall be set under another contract to the spacing shown on the drawings. The roofing contractor shall see that these are well secured with all nails well set, bolts or nuts countersunk, truly lined and evenly spaced, and shall not proceed until all faults have been corrected.

In general sheets shall be 96″ long and shall be laid with cross seams staggered. They shall be fastened by cleats not over 12″ apart and secured to sides of wood ribs. The cleats shall be locked to the sheets and the ribs shall be covered with a flashing cap locked over the cleats and edges of sheets on both sides.

All cross seams shall be flat-lock, and (**1**) unsoldered; (**2**) filled with white lead; (**3**) thoroughly sweated with solder, as specified under "Soldering." They shall be secured by cleats.

34. Battens or Ribs for Copper Roofing. (**Carpenters' Specification.**)

Where indicated on the drawings place on the roof sheathing wood battens or ribs shaped as detailed. The spacing of these ribs is approximately .... inches. The exact spacing shall be determined by the architect, and this contractor shall use a templet or gage-board to insure proper lining and spacing. They shall be firmly nailed with all nail heads set.

35. Standing Seam Roofing.

Seams shall be spaced as shown on the drawings.

All sheets shall be, in general, full length. They shall be laid with long edges turned up to form standing seams, and shall be secured by cleats not over 12" apart. No solder shall be used on standing seams. Cross seams shall be staggered.

All cross seams shall be flat-locked, and shall be, as indicated on drawings, (**1**) unsoldered. (**2**) filled with white lead; (**3**) soldered as specified under "Soldering." They shall be secured by cleats.

36. Flat Seam Roofing.

The roofing shall be applied the narrow way, joints staggered, using sheets not larger than 14" x 20".

All sheets shall be properly clipped and bent to form flat seams. Each sheet shall be secured to the roof with 2" x 3" copper cleats evenly distributed along the edges of each sheet, two on the long side, one on the short.

(**-1**) All sheets to be soldered shall be tinned all around and on both sides twice the width of the lock seam to be used.

(**-2**) Where white lead is used in the seams tinning shall be omitted.

37. Corrugated Copper Roofing and Siding.

Corrugated copper sheets shall have a side lap of at least one corrugation for siding and 1½ or 2 corrugations for roofing. End laps of sheets shall be at least 3" for siding and 6" for roofing.

All fastenings shall be of copper or copper alloy, and for roofing sheets they shall be applied through the high points of the corrugations.

When laid on steel purlins, the steel shall be insulated from the copper sheets by (**A**) asbestos strips, (**B**) lead strips or washers, (**C**) heavy asphalt paint over steel, (**D**) heavy tinning of steel.

38. Copper Roofing Details.

All details for copper roofing at hips, ridges, eaves, valleys, gable ends, and gutter and wall connections shall be carried out as specified elsewhere or as indicated by the architect on the drawings.

39. Copper Shingles and Tile.

These units shall be applied as called for in the manufacturers' specifications.

40. Flashings—Where required.

All intersections of roofs with vertical surfaces of every kind and all openings in roof and wall surfaces shall be flashed with copper. In addition copper flashings shall be installed wherever called for in the drawings. The method of flashing, except as otherwise shown or specified, shall be base and counter-, or cap, flashing.

41. Continuous Flashings.

Where the design or construction is such that the base and counter-flashing method is impracticable, flashings shall be made continuous from the roof surface up and into the vertical surface. Flashings of this type shall be made generally in two or more pieces, locked and soldered together. Where possible the joints shall be made by flat-lock seams. Otherwise lap seams shall be used.

42. Size of Sheets.

(**-1**) Strip copper shall be used for all flashings up to 18" in width.

(**-2**) In general, flashings for flat surfaces such as decks, crickets, etc., shall be of sheets not larger than 14" x 20". Under special conditions larger sheets may be used with the architect's approval.

(**-3**) All built-up and lined gutters shall be flashed with sheets of size specified under "Built-in Gutters." (See paragraph 65.)

43. Base Flashings.

(**-1**) Unless otherwise specified or shown on the drawings, base flashings shall be, in general, at least 6" high, and shall project at least 4" out on the roof. On sloping roofs they shall lap longitudinally at least 3". On flat roofs the joints shall be flat-locked and soldered.

(**-2**) Against stucco-coated walls, the metal lath shall lap outside the flashing so that the stucco shall finish over the flashing.

44. Cap Flashings or Counter-Flashings.

Cap flashings shall turn down over base flashings not less than 4", and shall have bottom edges turned back ½". They shall be secured to vertical surfaces as follows:

(**-1**) Wood Work. They shall extend up under exterior coverings such as shingles, slate, etc., at least 2" above the butt of the second course, and in no case less than 4" above the roof.

(**-2**) Masonry Work. They shall extend into joints of masonry walls at least 4" and have the inner edge turned up or back on itself at least ½". The sheets shall be bent to the required shapes, and built in with the masonry work. In existing walls not requiring through flashings, sheets shall be inserted not less than 2" and shall be secured with lead plugs 1" wide, 8" to 10" apart.

(**-3**) Reglets. They shall be secured, as specified below, in reglets cut in the masonry.

(**-4**) Stucco on Wood. When used with stucco-covered wood-frame walls, cap flashings shall be formed over a ¾" base board and extend up the wall at least 2" above the base board, and be nailed at the top edge with nails about 8" apart. Metal lath shall be placed over the flashing and the stucco shall be finished against the base board.

(**-5**) Stucco on Masonry. They shall be built into the masonry as the work progresses and shall

project out from the wall as required and turn down over the base flashing. The stucco shall finish against the cap flashing.

(-6) CONCRETE WALLS. They shall be set in the forms before the concrete is poured. They shall extend into the wall at least 2″ and shall have the inner edges turned back ½″.

45. Step Flashings.

Step flashings shall be used where vertical surfaces occur in connection with slopes.

They shall be formed of separate pieces built into the masonry as specified for cap flashings in masonry. Steps shall lap generally 3″, but in no case less than 2″, and shall not be soldered.

(-1) Lap joints shall be vertical.

(-2) Lap joints shall be normal to the roof slope.

46. Flashings. (Masons' Specification.)

Where indicated on the plans or specified, prepare for flashings to be installed and furnished by the sheet-metal contractor as directed by him.

47. Flashings for Clay and Cement Roof Tile.

Flashings shall be laid as specified elsewhere for base, cap, and continuous flashings. All base flashings running with the length of the tile shall extend out on the roof under the tile as far as possible without puncture by nails, and shall be formed into a trough by turning up the edge 90°. So far as possible flashings shall be laid to avoid sharp bends and angles, and shall not be nailed. They shall be held in place by the weight of the tile or by cleats. The manufacturer's specifications shall be followed for flashings of special shapes, etc.

Where vent-pipes occur the tiles broken by the pipes shall be bedded in mortar or secured with nails and covered with the flashing. Flashings shall extend down the roof to the end of the tile, out on the sides to the first lock or trough, and up the roof to and over the wood battens or to the nails securing the tiles.

Valley flashings shall be formed to fit the type of tile used and shall extend up the sides of the intersecting slopes, or be turned over the supporting wood battens, to form a valley at least 4″ deep.

Flashings against the sides of dormers, etc., on sloping roofs shall continue as a trough under the tile and discharge out on top of the tile below or into the gutter.

Exposed flashings shall extend with the length of the tiles at least 6″ and shall be formed over them. Those extending crosswise shall terminate in depressions or locks and be held in place by the adjoining tiles or by cleats.

48. Flashings for Built-up Roofing. (Roofers' Specification.)

When used with built-up roofing base flashings shall be not less than 5″ high and extend at least 6″ out on the roof, in accordance with Specification No. 156 of the Federal Specification Board for the Installation of Metal Flashings with Bituminous Built-up Roofings.

Cap-flashings shall be installed by the Sheet-Metal Contractor as specified elsewhere. The Roofing Contractor shall read carefully the sheet-metal specifications.

49. Flashings for Terra-Cotta.

Where indicated on the drawings terra-cotta shall be flashed to make a water-tight job. The top surfaces of all projections such as the washes of cornices, where the wash is formed of more than one piece, shall be completely flashed, and where so shown on the drawings all deck projections shall be so flashed.

Flashings shall be secured to the outer edge of terra-cotta projections by forming around a rolled nosing or bull-nose formed in the terra-cotta, or by brass screws set with lead sleeves into holes formed in the terra-cotta. The screws shall be set through washers and shall be soldered to the sheet. The sheet so secured shall extend down below the edge of the terra-cotta not more than ⅜″ to form a drip.

Cornices, band cornices, gutters, etc., formed in terra-cotta, or masonry faced with terra-cotta, shall have a continuous flashing running from the outside edge up to and behind the cap flashings.

Cap flashings shall be built in behind the terra-cotta facing above all cornices, etc. They shall extend up the wall at least 3″ and shall lap the cornice flashing 4″.

Balconies with balustrades shall have continuous flashings running from under the door or window sills through the balustrades and to the outside edge of the projection. Flashings shall be formed with flat-locked or lapped seams well soldered. Large areas shall be covered as in flat seam roofing.

Around column bases, etc., flashings shall be turned up and into a reglet formed in the terra-cotta, or into the first joint of the terra-cotta facing in such a manner as to make a water-stop.

Where rods, etc., necessary to support terra-cotta balustrades or other architectural members, penetrate the flashings, the joint shall be made water-tight as follows: The rods being in place, the flashing pieces shall be marked, punctured and set in position by sliding down over the rods; or, if this method is impracticable, the sheet may be slit to allow them to be slid into place. The slit shall be made tight by soldering a strip over it. Cups or thimbles, conforming roughly to the shape of the rod or bar then shall be placed over the rods and soldered to the sheet. They shall be at least 1″ larger all around than the rods. The cups shall then be filled with mortar or an approved waterproofing-compound.

50. Terra-Cotta. (Manufacturers' Specification.)

(-A) *Edges of all top pieces of projections to be flashed shall have formed on the vertical face holes about 9″*

apart, 3/8" in diameter, and at least 3/4" deep, for fastening the flashings.

(**-B**) *All edges to receive flashings shall have a rounded nosing around which the flashing sheet may be hooked and held firmly.*

Where indicated on the drawings or directed by the architect, holes shall be formed in the terra-cotta for securing flashing cleats. They shall be spaced about 12" apart.

51. Hips and Ridge Flashings.

(**-1**) Install hip and ridge flashings over roofing or battens set by other contractors. They shall be secured on either side of the roll by round-head brass wood-screws about 12" apart, set through washers. Holes in the roof covering shall be drilled. The heads of the screws and washers shall be covered with copper caps soldered to the flashing.

(**-2**) Hip and ridge rolls of design shown shall be installed over battens, etc., set by other contractors. The apron shall be held down by 3/16" x 1" brass bands 30" apart, secured to the batten by brass wood screws through countersunk holes.

52. Open Valley Flashings.

(**-1**) Open valleys shall be not less than 4" wide. The proper width shall be determined by the following rule: Starting at the top with a width of 4", increase the width 1" for every 8' of length of valley. Flashing pieces shall be full length sheets, and of sufficient width to cover the open portion of the valley and extend up under the roof covering not less than 4" on each side. The sheets shall not be punctured with nails.

There shall be no longitudinal seams in open valley flashings. The cross seams at the ends of sheets shall be lapped according to the pitch or locked and soldered. Edges shall be turned back 1/2" and held in place by cleats spaced not more than 12" apart and nailed to the sheathing with two copper or copper alloy nails.

(**-2**) "Fold-over" Flashings shall be used, of such design as to allow not less than 3" beyond the fold to be covered by the roofing. They shall be secured by cleats not more than 12" apart.

(**-3**) Where two valleys of unequal size come together, or where the areas drained by the valley are unequal, there shall be placed in the valley a "crimp," angle, or Tee not less than 1" high. This may be formed in the valley sheet before placing, or it may be made of a separate piece soldered to the valley sheet.

53. Closed Valley Flashings.

(**-1**) Built-In Method. Flashing pieces for closed valleys shall be of sufficient length to extend to or above the top of the roofing piece and lap the flashing piece below 3", and of width sufficient to extend up the sides of the valley far enough to make the valley 4" deep. They shall be placed with the roofing so that all pieces are separated by a course of shingles or slate. Pieces shall be set so as to lap at least 3" and to be concealed entirely by the roof covering. They shall be fastened by nails at the top edge only, or hooked over the tops of the underlying shingles.

(**-2**) Large Piece Method. Before the roof covering is laid this contractor shall place in all valleys long strips of copper of sufficient width to make a trough at least 4" deep. These strips shall be laid from bottom to top of the valley with a 4" lap, unsoldered. Where such strips are not over 12" wide they shall be fastened with nails spaced every 18" along the outer edge. Strips over 12" wide shall be fastened by 2" cleats, spaced every 30".

(**-3**) All closed valley flashings shall be made with a "crimp" or ridge down the center equal to the full thickness of the roof-covering courses.

54. Changes of Slope.

All changes of slope in shingle roofs shall be flashed with copper.

(**-1**) Exposed Flashings. On the upper slope the flashing shall extend as far as possible without being punctured by nails, and cleated, and on the lower slope it shall extend at least 3" over the shingles.

(**-2**) Concealed Flashings. On the upper slope the construction shall be the same as for exposed flashings. On the lower slope the flashing sheet shall be carried down between the shingles of the double course to within 1/2" of the butts. These shingles shall be fastened with countersunk brass screws passing through lead washers over the flashing.

55. Gable Ends.

Where called for, gable-ends shall be flashed with copper to render them watertight and weatherproof.

56. Finishes at Walls.

All joints between roofing and walls shall be flashed with copper, and unless otherwise specified flashings shall be cap and base, or through wall flashings.

Shingle Roofs. Flashing shall be by means of cap and base, or through wall flashings as specified elsewhere, or a concealed flashing. The concealed flashing shall be in one piece forming a concealed gutter at least 3" wide and carried under the roofing at least 4". It shall be secured to the wall as specified for cap flashings.

Tile Roofs. Flashings shall be as specified elsewhere.

Composition Roofs. Flashings for composition or laminated roofs shall be as specified elsewhere for Built-up roofing.

57. Wall Flashings.

Where called for in the specifications or shown on drawings, wall flashings shall be "through" flashings installed so as to provide complete cut-off for moisture and seepage. They shall be of the type and design determined by the architect, and if a

patented kind is called for they shall be installed according to the manufacturer's specifications.

All walls having copings shall be (**1**) covered with copper; (**2**) through-flashed with copper. Where dowels are used, they shall penetrate the flashing and be rendered water-tight as specified elsewhere.

58. Flashings Between Old and New Work.

Where new work is to be flashed against old work, such as at the junction between an old and a new building, the flashing shall be such as to allow for settlement.

(**-1**) Where the new wall is higher, the top of the old wall shall be covered with a flashing cap, extending completely over it and placed before the new wall is brought up. The old work shall then be flashed and counterflashed to the new, the base flashing being turned down over the old wall and locked to the cap, and the counter-flashing being built in with the new work as specified elsewhere.

(**-2**) Where the new wall is lower than an old wall, a flashing cap shall be placed over the new wall and turned down on both sides. The joint shall then be flashed and counter-flashed, the base flashing extending down over the new wall and locking to the cap. The counter-flashing shall be set in a reglet cut for it in the old wall and caulked with lead wool.

(**-3**) When the walls are level, the flashing shall consist of a cap continuous over both walls, properly sloped to shed water, and secured by brass wood-screws to the underside of a two-piece wood blocking secured on top of the walls by others. The flashing shall be in two pieces joined by a standing seam, or a loose-locked seam placed on one vertical side of the blocking so as to prevent leakage and to allow for settlement.

59. Water-table Flashings.

Water-table flashings shall extend up the sheathing at least 4″.

(**-1**) It shall be formed over the edge of the water-table to make a drip and shall be secured at the upper edge by nails 4″ apart.

(**-2**) If the edge-strip method of fastening is used the upper edge shall be nailed about every 8″.

60. Drips and Edge-Strips.

(**1**) Where indicated on the drawings, flashings shall be secured by brass edge-strips, 1/8″ thick by 1¼″ wide. Strips shall be fastened to the vertical face of the projection by brass screws about 12″ apart, and set to allow the copper flashing to be hooked over the lower edge at least 3/8″.

(**2**) Where indicated on the drawings, form drips of hard (cornice temper) copper strips. These shall be nailed to the projection and shall project not more than 3/8″ below the sheathing or the upper fillet of the molding, and shall have the flashing hooked over the lower edge at least 3/8″.

61. Eaves-Strips.

Install strips of copper along all eaves and roof edges except where gutters occur. They shall have a ½″ folded lower edge projecting 3/8″ below the sheathing or fillet of the molding to form a drip, and shall extend back on the roof 3″. They shall be installed in not exceeding 96″ lengths, with 2″ end laps, and shall be laid underneath the sheathing paper and nailed or cleated along the upper edge.

62. Eaves Trough and Hangers.

Eaves trough, or half-round hanging gutters, of the size and type shown, shall be installed where shown on the drawings. They shall be in 10′ lengths and shall be joined by a 1″ lapped and soldered joint, or by slip joints.

All joints shall be made in the direction of the flow.

Eaves trough shall be provided with end pieces, end caps, outlet tubes and mitres as required.

Eaves trough shall be supported by (**1**) wrought copper strap hangers of approved design; or (**2**) bronze or copper shank-and-circle-type hangers.

(**-1**) Wrought strap hangers shall be spaced not more than 36″ apart and shall be secured to the roofing by brass screws.

(**-2**) Shank-and-circle type hangers shall be adjustable for slope and shall be spaced not more than 36″ apart. They shall be secured by brass screws.

63. Molded Gutters.

Molded gutters of the size and design shown shall be installed where indicated on the drawings. They shall have a flange which shall extend up on the roof sheathing as far as possible without puncture by nails, and shall be held in place by cleats 30″ apart.

If impracticable to provide the flange, the gutter edge shall be locked and soldered to a flashing strip set as above specified.

The outer edge of the gutter shall be stiffened by a brass rod or rectangular bar, and provided with a proper drip. Braces of heavy copper or brass, spaced 30″, shall be locked around or riveted to the outer edge, and secured to the roof sheathing above the flange or flashing by two brass screws.

Joints of molded gutters shall lap 1″ and be secured with rivets spaced 2″, and soldered.

Outlets shall be provided with tubes soldered to the gutter of proper length to connect to the leaders.

64. Linings for Molded Gutters.

Where indicated on the drawings install gutter-linings of soft (roofing temper) copper. They shall be shaped to fit the bottom of the gutter and shall slope toward the outlet. All joints shall be lapped and soldered.

65. Built-in Gutter Linings.

Where indicated on the drawings, line all box or built-in gutters with copper. Gutter-linings shall fit loosely and shall have the back edge 2″ higher than the front edge. Back edges of linings shall lock to copper roof covering and when used with slate, tile or shingles shall lock to flashing extending up the

roof as far as possible without being punctured by the nailing of the roof covering, and secured with cleats.

(**1**) Small sheets shall be laid with seams staggered. All seams shall be flat-locked and soldered. Sheets shall be secured by cleats, and shall be 14" x 20".

(**2**) Large sheets used to form gutter-linings shall be laid the long way of the gutter. The ends of the sheets shall be flat-locked and soldered but left uncleated to form a continuous "floating" unit.

All gutter-linings over 24" wide shall have a longitudinal flat-lock seam running the length of the gutter, soldered and secured by cleats.

Linings shall be connected to flashings or to copper roofing by means of large loose-locked seams, folded flat and so placed as to avoid any possibility of leakage. In general the connection shall be made as close to the intersection of the roof slope and the inside of the gutter as is possible.

The back edge of all gutter-linings finishing against vertical walls shall be carried 4" above the outside edge and shall be covered by cap flashings built into the wall.

(**-1**) Gutter-linings in wood cornices shall have the front edges turned under the lower edge of a ⅛" by 1¼" brass strip screwed to the vertical face of the top member of the cornice. This strip shall be so placed as to form a proper drip.

(**-2**) Gutter-linings set in stone cornices shall be placed over a wood sheathing or nailing concrete forming the gutter slope. Outer edges shall be locked into a strip secured in a reglet. Where the wash-slope slopes out and the width of outer sheets of the lining exceeds 20", a standing seam shall be formed at the reglet.

(**-3**) Gutter-linings in concrete or brick work shall be secured to batten nailing strips or nailing concrete, set by other contractors according to directions by this contractor.

(**-4**) Gutter-linings formed back of copper cornices shall have the front edge locked to the top edge of the cornice.

66. Built-in Gutters. (Carpenters' Specifications.)

(**-1**) *Form gutters as shown on the plans, and as directed by the architect, of ⅞" boards with nail heads set and all surfaces smooth. Consult with the sheet-metal contractor on all details in connection with his work.*

(**-2**) *Set wood blocking and ⅞" sheathing in masonry gutters as shown on the plans and directed by the architect to form backing for lining sloped to outlets. Make all surfaces smooth with nail heads set. Consult with the sheet-metal contractor on all details in connection with his work.*

67. Build-in Gutters. (Mason's Specification.)

Cut all reglets for gutter-linings as shown on plans or directed by the architect. Set all battens and nailing strips in masonry necessary for the sheet metal work.

Form all depressions in masonry for outlet boxes as shown on the plans.

Form slopes to outlets in gutters and back of projections which are flashed.

All concrete surfaces to be covered with flashing shall be washed smooth with neat cement. Where cinders have been used in the concrete it shall be painted with two heavy coatings of asphalt paint.

Provide nailing concrete where called for in the drawings, with a smooth and even surface and of required depth.

Consult with the sheet-metal contractor on all details in connection with his work.

68. Pole Gutters and Gutter-Strips.

Where indicated on the drawings form gutters over wood poles or strips set by the carpenter contractor. Linings shall turn down over the pole and lock to a flashing strip, secured to the outer face of the pole by cleats and extending out over the roof covering at least 4".

Outlets shall be provided with tubes soldered to the lining and of length sufficient to connect to the leaders.

69. Expansion Joints.

(**-1**) ROOFS. Where expansion joints in the roof are shown on the drawings, these shall be formed or flashed with copper. Joints shall be provided in cornices, gutters, roofs, and walls to correspond to all building expansion joints called for to allow for the movement of the building.

(**-2**) GUTTERS. Where called for on the drawings provide expansion joints at high points, the full height of the gutters. The lining of the gutters shall be turned up and folded back to form flanges over which a cap shall be placed to form a water-tight joint. There shall be sufficient play between the cap and the flanges to allow for the full movement of the gutter and the building. The cap shall have soldered on its outer edge a V-shaped curb to turn water from the roof into the gutter.

70. Reglets.

Where indicated on the drawings or where directed by the architect flashings shall finish in reglets in the masonry cut by others where located by this contractor.

A flashing strip shall be turned into the reglet the full depth and shall be turned back to form a hook.

After the strip is in place in the reglet it shall be secured in place by plugs at about 12" spacing, using molten lead on flat surfaces, and lead wool on vertical surfaces.

After caulking, the reglet shall be made smooth by filling with elastic cement.

71. Reglets. (Masons' Specification.)

Where indicated on the drawings or where directed by the architect cut reglets in the masonry as located by sheet-metal contractor for the insertion of flashings.

Reglets shall be ½" wide at the top, ¾" wide at the bottom, and 1" deep. They shall be cut with true and straight edges, with sides and bottom roughened.

72. Flashings for Cornices.

All masonry cornices, band-courses projecting more than 12", balconies, balustrades, etc., shall be flashed with copper. Flashings shall be secured on the outer edge by reglets. The back edge shall be continuous at least 3" above the outer edge and in no case less than 4" high. Where stone facing on brick backing is used, cap flashings shall be set in and shall cover the base flashings.

Where stone balustrades occur on top of a cornice, etc., flashings shall be set in reglets under the balusters, or shall be continuous through the balustrade and either turn down over the interior roof base flashings as a cap flashing, or be connected thereto by a loose-locked joint. Dowels for fastening balustrade members together shall penetrate the flashing and shall be covered with a copper cap or thimble soldered to the flashing.

Flashings over 24" wide shall have a full-length longitudinal seam secured by cleats, and shall have a standing seam at the reglet.

73. Outlets for Built-in Gutters.

Outlets shall be formed as shown on the drawings. The gutter lining shall be turned into them and secured by soldered lap seams.

Holes shall be cut as soon as the lining is placed and temporary spouts shall be put in until the permanent drainage is ready.

Outlets shall be connected to leaders by

(**-A**) a 20-oz. copper tube;

(**-B**) a seamless copper tube.

Connections shall be flanged at the top and soldered to the outlet-box lining; the bottom shall have soldered to it a brass ferrule or caulking ring furnished by the plumbing contractor.

74. Roof Drains.

(**-1**) Approved types of patented roof drains may be used. They shall be furnished and set by the plumbing contractor and connection shall be made to them by the sheet-metal contractor in strict accordance with the manufacturer's directions.

(**-2**) Roof drains shall consist of a circular or square pan whose diameter or side shall measure at least 4" greater than the outlet, and have a depression of not less than 1½". They shall have a flashing extending out on roof surfaces, on all sides of the pan, not less than 6". The flashing or pan shall be provided with a rib forming a gravel-stop or of proper height to receive (**1**) built-up (**2**) promenade-tile roofing.

(**-3**) Roof drains shall consist of a copper flange extending out on the roof on all sides a distance at least equal to the size of the outlet. The flange shall be provided with a rib or gravel-stop against which to finish (**1**) built-up (**2**) promenade-tile roofing.

74a. Outlets from Drains.

Outlets from Drains shall consist of:

(**-1**) a 20-oz. copper tube, soldered to the (**A**) pan; (**B**) flange, and (**1**) extending into the drain pipe at least 6" with the outside coated with asphaltum; (**2**) with a brass ferrule or caulking ring soldered to the end of connection to the drain pipe by the plumbing contractor.

(**-2**) a seamless copper tube, flanged at the top and soldered to the (**A**) pan; (**B**) flange. Connections to the drain pipe shall be made by the plumbing contractor.

75. Roof Drains and Gutter Outlets. (Plumbers' Specification.)

(**-1**) *Furnish the sheet-metal contractor all brass ferrules necessary for connecting the drainage system and the roof drains and outlets shown on the plans, and connect copper tubes fitted with these ferrules to the drain pipes by caulked and leaded joints.*

(**-2**) *Furnish and install complete with all piping connections the patent drains shown on the plans. Make provision, where necessary, for the work of other trades in connecting to the drains.*

(**-3**) *Where shown on the plans furnish and install a seamless copper tube of a length necessary for the sheet-metal contractor to make a proper connection to the outlet-box or roof drain, and with a brass ferrule or caulking ring for connecting to the drain pipe.*

76. Strainers.

(**-A**) All outlets from gutters and roofs shall be provided with heavy, cast brass, removable strainers the full size of the outlet-box.

(**-B**) All gutter outlets shall be fitted with approved copper wire strainers of the basket type set in loosely.

77. Scuppers.

Flash all scuppers with copper, making same a part of the roof flashing. Scupper flashings shall cover the interior completely and shall extend through and project outside of the wall. Seams shall be locked, or lapped, and soldered. Scupper flashings shall be joined to roof flashings by soldered seams.

78. Scuppers. (Carpenters' or Masons' Specification.)

All enclosed roof surfaces, including balconies, etc., shall be provided with scuppers or auxiliary drains. The bottom of scuppers shall be not more than 2" above the finished roof surface at the lowest point.

79. Auxiliary Drains.

Auxiliary drains shall be so constructed that their outlets are separate from the main outlets and shall be at least 3" above the main outlets. They may be connected to the main drain by means of a Y branch.

80. Curbs.

Curbs around roof openings shall have a flashing turned down on the inside about 3" and secured with nails 1½" apart. It shall extend out on the roof as specified for base flashings.

81. Cricket or Saddle Flashings.

Crickets or saddles formed back of all vertical surfaces, such as chimneys, etc., breaking through sloping roofs, shall be covered with copper. The flashing of these crickets shall be made a part of the flashing along the sides of the chimney, etc.

82. Vent Flashings.

All pipes passing through roofs shall be flashed and counter-flashed. Base flashings shall extend out on the roof not less than 6".

(**-1**) They shall be of sufficient length to cover the roofing course next below the pipe and to extend up under the roofing course above as far as possible without puncture by nails.

(**-2**) Where vent-pipes extend more than 12" above the roof the counter-flashing shall be caulked into the hubs or held with brass clamps embedded in elastic cement or white lead. It shall lap the base flashing at least 4".

(**-3**) Where the vent extends not more than 12" above the roof surface, it shall be flashed as follows:

Cast Iron Pipe. The base flashing shall be carried up to within 1" of the top of the pipe and shall be counter-flashed by a copper cap 6" high, turned over and down into the pipe at least 2".

Threaded Pipe. The base flashing shall extend up to within 2" of the end of the pipe, which shall be threaded. After the flashing is in place the threads shall be covered with white lead and an iron or steel cap, of such design as to enclose the flashing material, shall be screwed onto the pipe.

(**-4**) Patented vent-flashing devices may be used, subject to the approval of the architect. They shall be made of 18-oz. copper, shall be the product of a recognized manufacturer, and shall be installed according to manufacturer's directions.

83. Ventilator Flashings.

Where metal ventilators are used on a roof they shall be connected to the flashing by a soldered lap seam. The flashing sheet shall extend out over the roofing on all sides at least 6".

(**-1**) On shingle or slate roofs the flashing shall be secured by round-head brass wood-screws set through holes drilled in the roof covering. The screws shall be set with slotted brass washers and shall be soldered to the flashing. The screws and screw holes shall be covered with soldered copper caps.

84. Guy-Anchor Flashings.

When bolts or similar devices penetrate sloping roof coverings, they shall be flashed as follows:

Before the courses above the bolt are laid, a piece of copper about 8" wide shall be placed over the lower roof covering and the sheathing with the bolt projecting through the hole in the center. The sheet shall be of sufficient length to lap the first course below the bolts 4" and extend up and under the courses above as far as possible without puncture by nails. The joint between the bolt and the sheet shall be closed by

(**-A**) Soldering to the sheet a flanged copper thimble placed around the bolt and caulked with waterproofing-compound.

(**-B**) Soldering the sheet to the bolt.

85. Flashing Around Steel Struts.

Where steel struts, etc., penetrate a flat roof, a copper pan about 2" high above the finished roof level shall be formed around the member. It shall have a flange projecting out on top of the roofing at least 2". This flange shall be soldered to the copper roofing, or with built-up roofing shall be covered with two layers of felt carried out on the roofing not less than 6" and well-mopped with pitch. The pan so formed shall be filled with pitch, and the top surface sloped to drain freely.

On sloping roofs the procedure shall be the same except that the sides of the pan shall be so proportioned as to retain the pitch.

86. Flag Pole Flashings.

(**-A**) Flag poles penetrating a flat roof shall have a circular base flashing extending up the pole at least 10" and 1" larger in diameter than the pole. It shall be turned out at the top to cut off drifting snow. A conical hood secured to the pole by a 1" brass band set in white lead and bolted, shall lap the base flashing at least 3". The whole flashing shall be so constructed as to allow for the movement of the pole.

(**-B**) Patented flashing-flanges or similar devices for flashing flag poles shall be used subject to the approval of the architect. They shall be the product of a recognized manufacturer and shall have a flashing of 18-oz. copper. They shall be installed in accordance with the manufacturer's directions.

87. Window and Door Head Flashings.

Window and door frames set in frame construction shall have a flashing of copper over the head. This flashing shall be set after the frame is placed and shall be carried up the wall 2" above the butt of the second course of shingles, slate, etc., and in no case less than 3" above the window head. The bottom edge of the flashing shall be

(**-A**) secured to the trim by an edge-strip as specified elsewhere.

(**-B**) turned down over the trim and shall finish back of, and be secured by, the outside molding of the trim.

(**-C**) nailed at 1" intervals to the vertical face of the trim.

(**-D**) bent at a sharp angle to bear tightly against the top fillet of the molding, and the upper edge of the flashing, under the shingles, shall be secured by nails placed about 8" apart.

88. Window and Door Sill Flashings.

(**-1**) Sill flashings for window frames in frame construction shall be set before the frame is placed.

They shall extend to the back of the window sill and shall be nailed after the frame is set, and shall also extend out to the face wall.

(**-2**) Wood sills set in stone or concrete shall have a strip of 20-oz. or heavier hard (cornice temper) copper or a bronze bar at the joint. Just before setting the wood sill the reglet shall be filled with waterproofing-compound and the strip shall be embedded in it.

89. Window and Door Sill Flashings. (Carpenters' and Masons' Specifications.)

The sills of wood frames set in stone or concrete shall have a slot 1" deep to receive a copper or bronze flashing strip. Stone or concrete sills under wood window or door frames shall have a 1" x 1" reglet cut or cast in them to receive a copper or bronze flashing strip.

90. Gravel-Stops.

Gravel-stops shall be placed at the edges of all built-up roofs covered with slag or gravel. They shall be formed of one piece of copper to provide a ridge the full height of the roofing material at the outer edge. They shall project on the roof at least 4", and be nailed on top of the waterproofing fabric, embedded in pitch, and covered with two layers of felt well-mopped with pitch.

91. Column-Cap Flashings.

The upper surfaces of all exposed column caps shall be flashed. The flashing shall be formed to fit the cap and shall be turned down ½" over the edge of the cap and fastened. A separate piece shall be fitted over the dowel and soldered to the main flashing.

92. Column-Base Flashings.

Bases of wood columns on a roof shall be flashed by a cap made to fit the dowel used to secure the column. The cap shall have a flange extending out on the roof on all sides the necessary distance to provide for water-proofing, as specified elsewhere for different kinds of roofing materials.

93. Scuttles.

Covers of roof scuttles shall be covered with copper. Sheets shall be laid with flat seams soldered, and shall be carried over the edge to the underside where they shall be secured with nails 1½" apart.

94. Skylights.

Where shown on the drawings, build skylights of size indicated and of approved design and manufacture, with curbs at least 10" above the roof. All sheet metal shall be 16-oz. hard (cornice temper) copper, reinforced where necessary for strength and stiffness with steel sections. Copper and steel shall be insulated by coating the steel with asphalt paint, or by using lead-coated copper. All sash bars and bearings for glass shall have condensation gutters leading to the outside of the skylight. All skylights shall be made water- and weather-tight with joints interlocked, riveted and soldered and shall conform to the requirements of the National Board of Fire Underwriters. Duplicate sets of detail drawings shall be submitted for approval.

95. Louvres.

Where shown on the drawings, louvres shall be formed of

(**-A**) copper,

(**-B**) wood covered with copper.

Duplicate sets of detail drawings shall be submitted for approval.

96. Copper Cornices.

Where shown on the drawings, cornices shall be erected of 20-oz. hard (cornice temper) copper. They shall be made in strict accordance with the profiles shown on drawings with moldings true, sharp and straight. All flat surfaces over 5" wide shall be crimped, all mitres and joints carefully fitted, angles and corners reinforced, and all joints neatly riveted and soldered together and made watertight. Cornice work shall be reinforced with properly-shaped steel brackets, separated from the copper by 3-lb. sheet lead.

The top edge shall be formed over a heavy brass or bronze edge-strip or drip properly shaped to permit the joining of the top flashing or gutter-lining as specified elsewhere.

Ornaments shall be stamped in soft (roofing temper) copper with dies made from approved models.

Duplicate sets of detail drawings shall be submitted for approval.

97. Copper-covered Walls.

On vertical walls marked "Copper," such as bulkheads, skylight curbs, penthouse walls, etc., erect standing seam or paneled surfaces as indicated. All standing seam work shall be fastened to wall surfaces with cleats nailed with copper nails to wood sheathing, or furring strips. All paneled work shall have casings or strips to receive copper. Crimped sheets shall be used for all large panels and large areas of plain surfaces.

98. Saw-Tooth Roofs.

Flashings for gutters in saw-tooth roof construction shall be carried up the sloping roof at least one foot beyond the "line of minimum-shadow" as indicated on the drawings, and shall be secured under the roof covering by cleats. Flashings shall be laid with flat seams, except on the vertical side where the flashings may be made with standing seams. Gutter-linings shall be made continuous and shall serve as base flashings for the window sill and side flashings.

Gutter-linings over 18" wide shall have a full length longitudinal flat-lock seam in the center of the gutter.

(Under carpenters' specification provide for snow racks of boards to prevent injury when gutters are cleared of snow.)

99. Leaders, Conductors, or Downspouts.

Leaders shall be installed where shown on the drawings, of the shapes and sizes indicated. They shall be held in position, clear of the wall, by

(**-1**) Brass hooks, driven into the wall not more than 6′ apart.

(**-2**) Heavy brass or copper straps, ⅛″ by 1½″, spaced not more than 6′ apart, soldered to the leaders, and fastened (**1**) to wood work by brass screws; (**2**) to masonry by brass screws set in lead sleeves.

(**-3**) Ornamental straps of (**1**) stock design; (**2**) the design shown, and made of (**1**) hard (cornice temper); (**2**) soft (roofing temper) copper.

Leaders shall be in 10′ lengths and shall have joints lapped. A 1½″ slip joint shall be provided every 20′ of leader.

When leaders connect with underground drains they shall be fitted into drain-pipes and shall have the joint neatly cemented. All leaders not so connected shall have elbows at the bottom. Those discharging at ground level shall have heavy shoes with reinforced ends.

100. Leader Heads.

Leader heads of (**1**) stock design; (**2**) the design shown, shall be placed where indicated on the drawings. Outlet tubes from gutters shall extend into them about 2″. The leader head outlet shall extend at least 2″ into the leader.

Large leader heads (12″ wide or over) shall have a heavy copper-wire removable screening over the top.

101. Snow-Guards. (Roofers' Specification.)

(**-1**) *Furnish and erect on sloping roofs approved copper wire snow-guards spaced not more than 18″ apart in both directions and staggered.*

(**-2**) *Furnish and set at eaves a snow-stop consisting of three ½″ bronze bars set in approved manner with bronze supports.*

102. Ice-Box Drain-Pan.

Form ice-box drain-pan 2″ deep of 20-oz. hard (cornice temper) copper with lap seams. The sides shall be stiffened by a roll at the top. The pan shall be not less than 16″ square and shall have a 1½″ outlet. The outlet shall have a tube soldered to the pan of sufficient length for connection to the waste line by the plumber.

103. Cleaning Copper.

All copper work when finished shall be thoroughly cleaned of all flux, scraps and dirt. On large areas this shall be done as each section of the work is finished. Excess flux which may cause acid stains shall be neutralized by washing with a 5% to 10% solution of washing soda (or a solution of about one pound of lye in a pail of water.) After cleaning the copper shall be washed off with clear water.

104. Coloring Copper.

(**-1**) Green Patina. . . . . (See remarks on this subject on page 18 of this book.)

(**-2**) Brown or Bronze. Clean the copper of all foreign substances and debris and rub it thoroughly with waste soaked in boiled linseed oil until the desired color is obtained. Touch up solder with copper bronze.

105. Painting Copper.

Copper shall first be thoroughly cleaned, free from dirt and grease, and absolutely dry. If possible the copper shall be permitted to weather through several rainstorms until the surface takes on a slight tarnish from its oxidation by the atmosphere. Lead base paints shall be used for painting all copper work.

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SECTION VI

MISCELLANEOUS DATA & TABLES

TABLE I

PHYSICAL PROPERTIES OF COPPER

A. General and Thermal

Atomic weight (Cu)	63.57
Density annealed Copper at 20° C.	8.94
Melting point	1980° F. or 1083° C.
Thermal conductivity (Silver = 100)	92.6
Latent heat of fusion	50.46 calories per gram
Specific heat at 25° C.	0.0919 calories per gram per °C.
Specific heat at t° C.	0.0919+0.000048 (t—25)
Coef. of linear expansion per °C.	0.000017
Coef. of linear expansion per °F.	0.0000095
Weight, rolled copper, lbs. per cu. in. at 68° F.	0.322
Weight, cast copper, lbs. per cu. in.	0.31
Shrinkage about	0.1875″ per foot

B. Mechanical

Modulus of Elasticity (electrolytic copper at 20° to 100° C.):	LBS. PER SQ. IN.
Hard Drawn	17,600,000
Annealed	18,300,000

Tension (pure copper worked and then annealed):	
Elastic or proportional limit	Not determinable
Elongation in 2″	40% to 60%
Reduction of area	40% to 60%

Ultimate Strength:	LBS. PER SQ. IN.
Cast	22—36,000
Forged	34,000
Bolt	36,000
Sheet	36,000
Wire	62,000

Compression:

Copper of good quality does not fracture in compression but flattens out.

Torsion:

$$d' = \sqrt[3]{\frac{5.1\,F\,L}{S'}}$$

d′ = diameter in inches.
F = torsional force in pounds.
L = lever arm inches.
S′ = from 15,000 to 30,000 lbs. per square inch.

Shear Test:

The shearing resistance of copper may be taken as equal to the ultimate strength in tension and subject to the same variations, i.e.:

	LBS. PER SQ. IN.
Cast Copper	22—36,000
Copper Sheet	36,000
Copper Forged	34,000

Transverse Bending Test:

Modulus of rupture, 20,000 to 40,000 lbs. per square inch.

Hardness:

Mohrs mineralogic scale .... 2.5—3

Martens sclerometer

10 g gave a scratch of 0.014 to 0.016 mm.

17 g gave a scratch of 0.022 to 0.027 mm.

Scleroscope (universal hammer):

Annealed Copper .... 6 to 7

Hard Copper (cold reduction 66%) .... 22 to 24

Brinell:

Annealed or Cast Copper (500 kg. load 10 mm. ball) .... 30 to 40

When hardened by cold working, the above value may run as high as 100

Per Cent Cold Reduction of Section	Brinell Hardness Numeral—500 Kg.		Tensile Strength lbs. per sq. in.	Elongation in 2 ins. Per Cent
	10 mm. ball	5 mm. ball		
0 (soft annealed)	42	50	33,600	46
10	70	74	36,000	24
20	81	81	40,000	13
30	86	90	45,000	5
40	94	92	47,800	4.5
50	96	95	52,600	4.2

Tensile Strength—High Temperatures:

Temperature		Pure Copper		Copper—Bengough's Figures	
°C.	°F.	T. S. Lbs. Per Sq. In.	Elongation %	T. S. Lbs. Per Sq. In.	Elongation % in 2″
17	63	......	......	32,600	32.5
20	68	34,000	43	......	......
100	212	30,000	38	......	......
200	392	27,500	37	......	......
252	486	......	......	25,400	28.0
300	572	24,000	36	......	......
330	627	......	......	22,000	29.6
400	752	19,000	20	......	......
420	788	......	......	19,000	28.3
480	896	......	......	15,000	27.5
500	932	14,000	24	......	......
540	1004	......	......	10,200	27.0
620	1148	......	......	5,200	27.0
675	1215	......	......	2,600	28.4
736	1357	......	......	2,400	36.0
840	1544	......	......	1,920	61.0
920	1770	......	......	1,000	69.0
1010	1850	......	......	320	38.0

TABLE II

THICKNESS OF STANDARD COPPER SHEETS

Rolled to Weight

Weight per Sq. Ft.		Thickness	Nearest Gauge No.		Nearest Fraction
Ounces	Pounds	Inches	B. & S.	Stubs	
	16	.3456	00	00	11/32
	15	.3240	0	0	21/64
	14	.3024	1	1	19/64
	13	.2808	1	2	9/32
	12	.2592	2	3	1/4
	11	.2376	3	4	15/64
	10	.2160	4	5	7/32
	9½	.2052	4	6	13/64
	9	.1944	4	6	
	8½	.1836	5	7	3/16
	8	.1728	5	8	11/64
	7½	.1620	6	8	
	7	.1512	7	9	5/32
	6½	.1404	7	10	9/64
	6	.1296	8	10	1/8
	5½	.1188	9	11	
80	5	.1080	10	12	7/64
72	4½	.0972	10	13	3/32
64	4	.0864	11	14	
56	3½	.0756	13	15	5/64
48	3	.0648	14	16	1/16
44	2¾	.0594	15	17	
40	2½	.0540	15	17	
36	2¼	.0486	16	18	3/64
32	2	.0432	17	19	
28	1¾	.0378	19	20	
24	1½	.0324	20	21	1/32
20	1¼	.0270	21	22	
18	1⅛	.0243	22	23	
16	1	.0216	23	24	
14	⅞	.0189	25	26	
12	¾	.0162	26	27	1/64
10	⅝	.0135	27	29	
8	½	.0108	29	31	
6	⅜	.0081	32	33	
4	¼	.0054	35	35	
2	⅛	.0027			

Variations from these weights must be expected in practice.

TABLE III

WEIGHT OF COPPER SHEETS

Brown & Sharpe's Gauge			Stubs' Gauge			Inches and Fractions	
No.	Decimal Equivalent Inches	Pounds per Sq. Ft.	No.	Decimal Equivalent Inches	Pounds per Sq. Ft.	Thickness	Pounds per Sq. Ft.
0000	.4600	21.30	0000	.454	21.02	1/16	2.894
000	.4096	18.97	000	.425	19.68	1/8	5.788
00	.3648	16.89	00	.380	17.59	3/16	8.681
0	.3249	15.04	0	.340	15.74	1/4	11.58
1	.2893	13.39	1	.300	13.89	5/16	14.47
2	.2576	11.93	2	.284	13.15	3/8	17.36
3	.2294	10.62	3	.259	11.99	7/16	20.25
4	.2043	9.460	4	.238	11.02	1/2	23.15
5	.1819	8.424	5	.220	10.19	9/16	26.04
6	.1620	7.502	6	.203	9.399	5/8	28.94
7	.1443	6.681	7	.180	8.334	11/16	31.83
8	.1285	5.949	8	.165	7.639	3/4	34.73
9	.1144	5.298	9	.148	6.852	13/16	37.62
10	.1019	4.718	10	.134	6.204	7/8	40.51
11	.09074	4.201	11	.120	5.556	15/16	43.41
12	.08081	3.741	12	.109	5.047	1	46.30
13	.07196	3.332	13	.095	4.399	1 1/16	49.19
14	.06408	2.967	14	.083	3.843	1 1/8	52.09
15	.05707	2.642	15	.072	3.334	1 3/16	54.98
16	.05082	2.353	16	.065	3.009	1 1/4	57.88
17	.04526	2.096	17	.058	2.685	1 5/16	60.77
18	.04030	1.866	18	.049	2.269	1 3/8	63.66
19	.03589	1.662	19	.042	1.945	1 7/16	66.56
20	.03196	1.480	20	.035	1.621	1 1/2	69.45
21	.02846	1.318	21	.032	1.482	1 9/16	72.35
22	.02535	1.174	22	.028	1.296	1 5/8	75.24
23	.02257	1.045	23	.025	1.158	1 11/16	78.13
24	.02010	.9307	24	.022	1.019	1 3/4	81.03
25	.01790	.8288	25	.020	.9260	1 13/16	83.92
26	.01594	.7381	26	.018	.8334	1 7/8	86.81
27	.01420	.6573	27	.016	.7408	1 15/16	89.71
28	.01264	.5853	28	.014	.6482	2	92.60
29	.01126	.5212	29	.013	.6019		
30	.01003	.4642	30	.012	.5556		
31	.008928	.4134	31	.010	.4630		
32	.007950	.3681	32	.009	.4167		
33	.007080	.3278	33	.008	.3704		
34	.006305	.2919	34	.007	.3241		
35	.005615	.2600	35	.005	.2315		
36	.005000	.2315	36	.004	.1852		
37	.004453	.2062					
38	.003965	.1836					
39	.003531	.1635					
40	.003145	.1456					

Variations from these weights must be expected in practice.

TABLE IV

COMPARISON OF WIRE GAUGES

Gauge No.	American or Brown & Sharpe's	Birmingham or Stubs'	Wash. & Moen	Imperial S. W. G.	London or Old English	United States Standard	Gauge No.
0000000			.4900	.500		.500	0000000
000000	.5800		.4615	.464		.46875	000000
00000	.5165		.4305	.432		.4375	00000
0000	.4600	.454	.3938	.400	.454	.40625	0000
000	.4096	.425	.3625	.372	.425	.375	000
00	.3648	.380	.3310	.348	.380	.34375	00
0	.3249	.340	.3065	.324	.340	.3125	0
1	.2893	.300	.2830	.300	.300	.28135	1
2	.2576	.284	.2625	.276	.284	.265625	2
3	.2294	.259	.2437	.252	.259	.25	3
4	.2043	.238	.2253	.232	.238	.234375	4
5	.1819	.220	.2070	.212	.220	.21875	5
6	.1620	.203	.1920	.192	.203	.203125	6
7	.1443	.180	.1770	.176	.180	.1875	7
8	.1285	.165	.1620	.160	.165	.171875	8
9	.1144	.148	.1483	.144	.148	.15625	9
10	.1019	.134	.1350	.128	.134	.140625	10
11	.09074	.120	.1205	.116	.120	.125	11
12	.08081	.109	.1055	.104	.109	.109375	12
13	.07196	.095	.0915	.092	.095	.09375	13
14	.06408	.083	.0800	.080	.083	.078125	14
15	.05707	.072	.0720	.072	.072	.0703125	15
16	.05082	.065	.0625	.064	.065	.0625	16
17	.04526	.058	.0540	.056	.058	.05625	17
18	.04030	.049	.0475	.048	.049	.05	18
19	.03589	.042	.0410	.040	.040	.04375	19
20	.03196	.035	.0348	.036	.035	.0375	20
21	.02846	.032	.0317	.032	.0315	.034375	21
22	.02535	.028	.0286	.028	.0295	.03125	22
23	.02257	.025	.0258	.024	.0270	.028125	23
24	.02010	.022	.0230	.022	.0250	.025	24
25	.01790	.020	.0204	.020	.0230	.021875	25
26	.01594	.018	.0181	.018	.0205	.01875	26
27	.01420	.016	.0173	.0164	.01875	.0171875	27
28	.01264	.014	.0162	.0148	.01650	.015625	28
29	.01126	.013	.0150	.0136	.01550	.0140625	29
30	.01003	.012	.0140	.0124	.01375	.0125	30
31	.008928	.010	.0132	.0116	.01225	.0109375	31
32	.007950	.009	.0128	.0108	.01125	.01015625	32
33	.007080	.008	.0118	.0100	.01025	.009375	33
34	.006305	.007	.0104	.0092	.00950	.00859375	34
35	.005615	.005	.0095	.0084	.00900	.0078125	35
36	.005000	.004	.0090	.0076	.00750	.00703125	36
37	.004453		.0085	.0068	.00650	.006640625	37
38	.003965		.0080	.0060	.00575	.00625	38
39	.003531		.0075	.0052	.00500		39
40	.003145		.0070	.0048	.00450		40
41	.002800		.0066	.0044			41
42	.002494		.0062	.0040			42
43	.002221		.0060	.0036			43
44	.001978		.0058	.0032			44
45	.001761		.0055	.0028			45
46	.001568		.0052	.0024			46
47	.001397		.0050	.0020			47
48	.001244		.0048	.0016			48
49	.001018		.0046	.0012			49
50	.0009863		.0044	.0010			50

Sheet 16 ga

TABLE V

STANDARD STOCK SIZES—SHEET, ROLL AND STRIP COPPER

A. Sheet Copper

(soft and hard)

Widths	Length	Thickness (oz. per sq. ft.)
20″-24″-28″-30″-36″	96″	14
20″-24″-26″-28″-30″-32″-36″	96″	16
24″-30″-36″	120″	16
24″-30″-36″	96″	18
24″-30″-36″	96″	20
30″-36″	96″	24
30″-36″	96″	32

B. Soft Copper in Rolls

Widths	Thickness (oz. per sq. ft.)	Av. Length per Roll (feet)
10″	14	117
12″	14	98
14″	14	84
16″	14	73
6″	16	170
8″	16	127
10″	16	102
12″	16	85
14″	16	73
16″	16	64
18″	16	57
20″	16	51

C. Cold Rolled Strip Copper

Size	Thickness (oz. per sq. ft.)	Approx. Wt. per Strip (pounds)
10″ x 96″	16	6.67
12″ x 96″	16	8.00
14″ x 96″	16	9.33
10″ x 120″	16	8.33
12″ x 120″	16	10.00
14″ x 120″	16	11.67

ROLL AND STRIP COPPER

Strip copper is coming more and more into use for flashings. It has several advantages; some of which are its cheaper price; its workability. It can be purchased in small quantities at a cost somewhat lower than sheets, and there is practically no waste. It is made in all widths up to 20 inches.

The process of manufacture is such that straight edges are obtained. Heretofore, this has been an objection to long sheets of copper.

Strip copper is readily obtainable in rolls about 75 feet long. It is also made by some mills in convenient lengths up to 10 feet. It is generally best to cut the copper to length on the job, for the actual conditions can best determine the lengths needed.

ACCEPTED TOLERANCE PRACTICE

1. Scope:

The practice set forth herein shall apply to both soft (roofing temper) and hard (cornice temper), copper sheet and strip.

2. Thicknesses:

For determining tolerances, the thickness of copper sheets and strips for general sheet-metal purposes in building construction, shall be taken as at 68 degrees Fahrenheit:

14-ounce......................0.0189 in.
16-ounce......................0.0216 in.

3. Weight Tolerances:

(a) Weight tolerances of copper sheet or strip shall be determined by case and crate lots and not by single sheets or strips.

(b) All case and crate lots of copper sheet or strip shall weigh not less than 95% nor more than 103% of the theoretical weight.

(c) Weight shall be based on case or crate lots containing not less than 500 lbs.

4. Single Strips.

The minimum thickness of any single sheet or strip at any single point shall be:

for 14-ounce..................0.0160 in.
for 16-ounce..................0.0190 in.

5. Gaging:

(a) For test of thickness micrometer readings shall be made on 10% of the sheets or strips in each case or crate lot.

(b) Each sheet or strip selected shall be gaged at evenly spaced points along both edges, and in the center at both ends.

MATERIAL ESTIMATES FOR ROOFING

In estimating the amount of sheet copper which is required to cover a given roof area, the type of roofing, size of sheets, size of seams, and size of spacing of cleats must all be considered. To facilitate estimates the approximate quantities resulting from the commonly used sheet sizes in the three different types of copper roofing have been tabulated in Table VI.

The first column gives the square feet of copper required to cover an area of 100 square feet. The figures are based on 2″ x 2″ tapered battens, 1 inch finished standing seams and ½-inch flat-lock seams.

The amount for cleats given in the second column assumes a spacing of 8 inches for batten and standing seam roofing, and two cleats on the long sides and one on the short sides of the sheets in the flat seam construction. Cleats are assumed 2 inches wide in all cases.

The third column gives the quantity of 1-inch nails required assuming two nails per cleat and 270 nails per pound.

The last column is a sum of the first two, and represents the total amount of sheet copper required per roofing square. These factors can be used as percentages to be applied to the total square feet of roof to be covered, to give the square feet of copper required.

TABLE VI

APPROXIMATE MATERIAL QUANTITIES PER ROOFING SQUARE (100 SQ. FT.)

	Copper Sheets (sq. ft.)	Copper Cleats (sq. ft.)	1-Inch Nails (lbs.)	Total Sheet Copper (sq. ft.)
*Batten Seam—24″ x 96″ sheets	134	6	1⅓	140
Batten Seam—30″ x 96″ sheets	127	5	1	132
*Standing Seam—20″ x 96″ sheets	118	4	1	122
Standing Seam—24″ x 96″ sheets	115	3	⅔	118
*Flat Seam—14″ x 20″ sheets	121	7	1½	128
Flat Seam—18″ x 24″ sheets	117	4	1	121

*Recommended sizes.

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